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EDITORIAL.

ITEMS AND NOVELTIES.

The Girard Avenue Bridge, Philadelphia.—We present herewith a well-executed engraving, from Messrs. Van Ingen & Snyder, of this city, representing a view of the new bridge over the Schuylkill at Girard avenue, which will, when completed, form the chief highway to that portion of Fairmount Park in which it is intended to place the buildings of the International Exposition of 1876.

For the following abstract of the details of the new structure we are indebted to the Pennsylvania Engineer and Manufacturer.

The Councils of the city of Philadelphia have decided that this bridge shall represent the highest level to which the art of iron bridge building has yet attained.

The contract for the work has been awarded to the Phœnix Iron Works, at Phœnixville, Pa.

It is decided that the bridge shall be 100 feet wide, which is stated to be wider than any bridge yet constructed. It allows of seven lines of carriages, driving abreast on the roadway, and has two lines of sidewalks about fifteen feet in the clear.

The widest bridges in Europe are the new Westminster and the new Waterloo bridges, at London, which are respectively eighty and eighty-five feet in width.

The design being that no perishable materials shall enter into the construction of the new bridge, it is specified that upon the iron floor joists shall be laid corrugated iron plates, and that these be covered with asphalt concrete, which, while forming a perfectly water-tight surface, shall yet be tolerably elastic. Upon this is to come a pavement of granite blocks laid in cement.

For each track there is designed to be a tramway, consisting of two lines of smooth flags, twelve inches wide, upon which the wheels of vehicles will run. The tramways are not to project above the general surface.

The sidewalk will consist of slate or flags, also laid in cement, and bordered with bright colored tiles. Between the sidewalks and the roadways will be placed iron railings of ornamental design, secured to the granite curbstone.

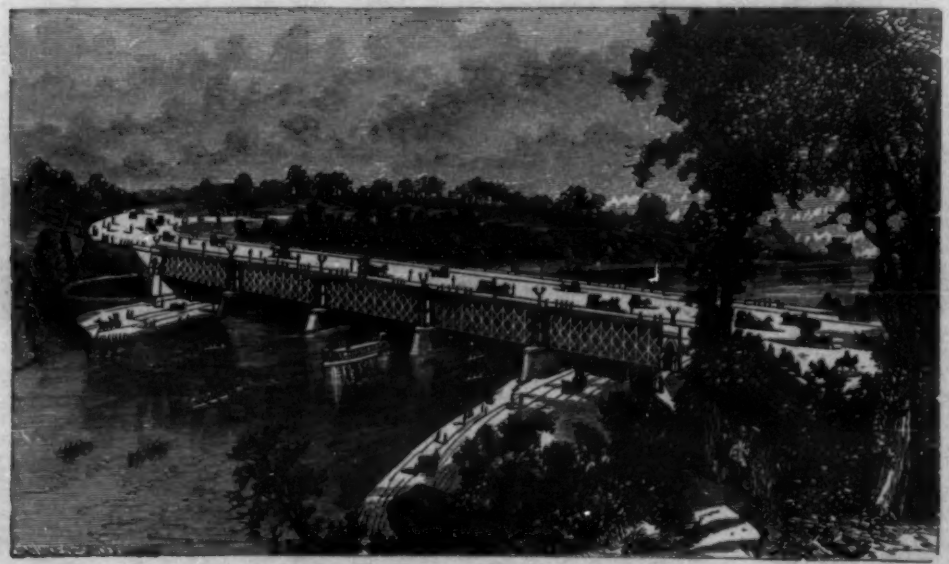
It is designed to make this structure architecturally as elegant as possible, in realizing which the work itself will be ornamented instead of applying constructed ornamentation.

The balustrade in the outer line of the sidewalks will have bronze panels worked with elaborate designs. There will be a richly ornamented cornice and frieze below this, about three feet and a half deep. The iron work of the supporting trusses will be picked out in colors and gold. The piers and abutments will be constructed of Maine granite. The dressed work abutments will be constructed of such stone as will give contrast of color. There will be a margin or factor of safety of five times the strength required to sustain a fixed and moving load of three hundred pounds per square foot.

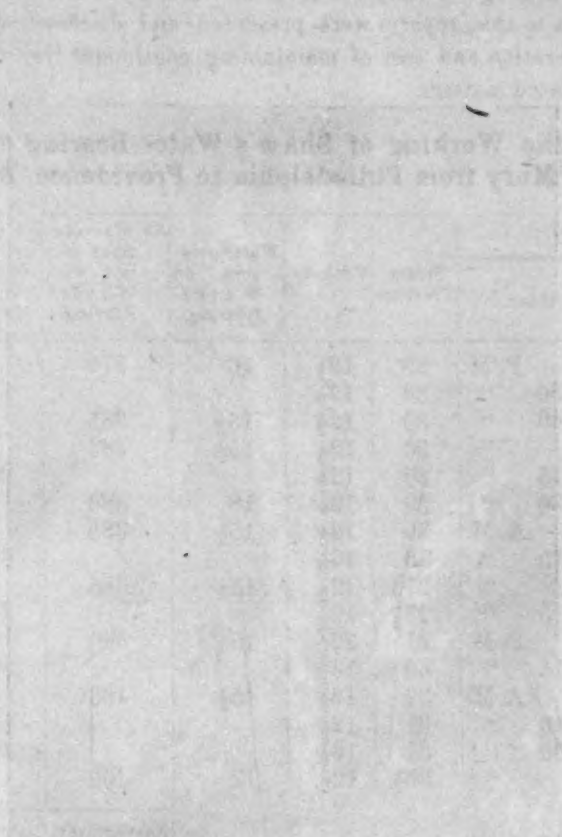
The upper chords and vertical posts will be made of Phœnix columns. The tension members of Phœnix weldless link bars. The bridge is to be completed within eighteen months.

American Railroad Master Mechanics Association.—The sixth annual convention of this body has just finished its sittings at Baltimore, Md. One hundred and thirty members were in attendance. Seventeen new members were received. Amongst other interesting business we have space to notice that the Committee on Boiler Incrustation was continued, and that Messrs. Coleman Sellers, of Philadelphia, and Peebles, of New Jersey, were added to it.

The subject of the chemical examination of waters used in locomotive boilers, and the comparative value of anthracite and bituminous coal and wood in generating steam, excited considerable discussion,



GIRARD AVENUE BRIDGE, PHILADELPHIA.



a report upon the latter subject being read before the meeting. Mr. W. W. Evans read a paper on the relative cost of operating roads of 3 feet 6 inches gauge or less, and those of 4 feet 8½ inches gauge.

In addition to this, reports were presented and discussed on construction, operation and cost of maintaining continuous train brakes and other related matters.

Report of the Working of Shaw's Water-Bearing on the Steamer Mary from Philadelphia to Providence, R. I.

May, 1873. Day of Month.	Hour.	Steam Pressure	Vacuum.	Water pressure on Water-Bearing.	No. of revolutions in 5 min. with Water-Bearing.	No. of revolutions in 5 min. with old Bearing.
May 10	9 P. M.	29	12½	16	370	
"	9·30 "	30	12½			368
"	9·40 "	30	12½	15½	385	
"	10 "	30	12½	15½	383	
"	10·15 "	30	12½			373
"	10·30 "	29	12½	18	380	
May 11	9 A. M.	30	12½	15½	385	
"	9·15 "	30	12½			380
"	11 "	27½	12½	15½	386	
"	11·15 "	27½	12½			373
"	4 P. M.	31	12½	15½	390	
"	4·15 "	30	13½			383
May 12	9 A. M.	32	12½	15½	408	
"	9·15 "	31	12½			373
"	9·30 "	31	12½			396
"	10 "	30½	12½	17	402	
					Average revolutions in 5 min·, 387·6.	Av'rge revs. in 5 min., 380.7.
					Av'rge steam and vacuum, 42.2.	Av'ge steam & vacuum, 42.4.

The area of water surface on Shaw's Bearing is 277·4 at maximum load 17 lbs. water pressure = 4·709 lbs. total end thrust.

The engine is 38 in. diam. × 34 in. stroke, with surface condenser. A superior working engine with adjustable cut-off set at 10 inches. Built by Neafie & Levy, of Philadelphia.

It is proper to remark that the thrust-bearing recently placed on shaft by Neafie & Levy is a very superior bearing, with new polished

and well oiled surfaces; otherwise the difference between the two bearings would be more prominent in point of revolutions.

The thickness of water in Shaw's Water Bearing is five inches, and it is upon this disc or slice of water that the entire load of end thrust is made to float; the metallic surfaces being five inches apart, there is no possible chance of the surfaces to reach each other to cause cutting or grinding, as in the ordinary plan; therefore one of Shaw's Bearing might be run for fifty years without even rubbing tool marks out, which, of course, will make considerable saving in the item of repairs.

Shaw's Water Bearing is a perfect dynanometer, indicating the actual power to propel the ship, the effect of which can always be noticed upon the gauge communicating with the water bearing.

It will be evident that the almost total absence of friction in Shaw's Water Bearing does away with all apprehension of heating the thrust-bearing—one of the greatest annoyances the engineer has to contend with.

JOSEPH L. PARRY, *Engineer.*

The New Bridge at Fairmount.—Work has already begun upon the new iron structure intended to replace the present, and once famous, wire structure across the Schuylkill, at Fairmount. The new bridge is arranged to have two roadways, one above the other. The east approach, for the upper roadway, will commence at Twenty-fifth street opposite to Spring Garden Street. It will pass alongside of the reservoir, and reach an elevation of thirty-two feet above Callowhill Street, at a point near to the entrance of Fairmount Park. There will be two towers of masonry at each end of the bridge, erected upon the present abutments. From the western end of the bridge to Thirtieth Street there will be an approach similar to the one on the east side, with a bridge at Thirtieth Street, having a clear span of 80 feet. From this point, for a distance of 140 feet, the upper roadway will be sustained by retaining walls, terminating at each end with abutments. There will be three spans of plate girders over the Pennsylvania Railroad.

From the Pennsylvania Railroad to Thirty-second Street the grade of the street as now used will be changed, so as to descend regularly, and cross the rails at an elevation of 24·8 feet. The lower roadway will commence on the east side at the angle in Callowhill Street, upon the level as now in use, passing under the colonnade upon a level approximating to the present roadway to Thirtieth Street.

The bridge, of the truss pattern, will be 348 feet from centre to centre of end ports, and 34 feet high from lower to top chord.

The upper roadway will be 50 feet wide with a carriage way of 32 feet, and an 8 foot footway on each side. The lower roadway will be 27 feet, with footways varying from 12 to 15½ feet in width. The weight of the iron structure will be 5½ tons per lineal foot. The bridge is expected to be completed in 1874.

A New Water Tunnel for Chicago.—The capacity of the water works of the city of Chicago, about 54,000,000 gallons, has been found insufficient to meet the wants of its growing community, in consequence of which an enlargement of the same has been determined on and is now in course of completion.

It will be remembered that the city is supplied from Lake Michigan, by means of a tunnel beneath its bottom—extending out about two miles into the lake. To meet the growing demand for greater supply, contracts for the construction of another tunnel have been made, and the work is now in operation. The new tunnel is to be seven feet in diameter and six miles in length, of which four miles extend beneath the city and two beneath the lake.

The New York *Times* contains the information that "the laborers on the shore end have progressed some 2000 feet out under the lake, while from the crib end another body of men are working forward to meet them. The limited diameter of the bore renders it impossible for many to work at once, but the work is pressed forward night and day, averaging at each end perhaps twelve feet in twenty-four hours. The masons keep as close behind the diggers as possible. The soil penetrated is a hard blue clay, and such a thing as a caving in has not happened thus far. A tin tube, eight inches in diameter, is constantly advanced with the workmen, thus furnishing a circulation which prevents the accumulation of foul air.

"The new tunnel runs parallel with the old one, distant from it about fifty feet. It will deliver its supply at the new works, at the corner of Ashland and Blue Island Avenues, three and five-sixths miles from the old ones; and to reach it the new tunnel is to be extended under the city, river, large business houses and all. It is estimated that the cost will be somewhere in the neighborhood of $1,000,000." * * * * * *

The land tunnel as well as its lake connection is to have a vertical diameter in the clear of seven feet two inches, and a horizontal di-

ameter of seven feet. Its capacity will be over 100,000,000 gallons per day. It will be lined with heavy masonry a foot thick, and of the best materials. January 1st, 1875, is specified as the date of its completion.

American Association for the Advancement of Science.—We have received the annual circular of this National Association, from which we learn that its twenty-second annual meeting will be held in Portland, Maine; commencing Wednesday, August 26th.

The officers of the coming meeting are: President, Joseph Lovering, of Cambridge, Mass.; Vice-President, A. H. Worthen, of Springfield, Ill.; General Secretary, C. A. White, of Iowa City, Iowa; Treasurer, Wm. S. Vaux, of Philadelphia, Pa.; Permanent Secretary, F. W. Putnam, of Salem, Mass. Standing Committee, J. Lawrence Smith, of Louisville, Ky.; Alexander Winchell, of Syracuse, N. Y.; E. S. Morse, of Salem, Mass., together with the officers of this meeting, already named. As the Local Committee appears to be an energetic one, the coming meeting promises to be one of more than ordinary interest.

Improvement in Manufacture of Coal Gas.—The process of Mr. Eveleigh, which is at present attracting considerable attention abroad, consists in, 1st, Distilling the coal destructively at a comparatively low temperature; 2d, Producing a gas rich in heavy hydro-carbons by the distillation of the oil and tar resulting from the first distillation. It is claimed that by this process, while the working expenses of the works are not materially increased, the quantity and quality of the gas and coke are decidedly increased. Experiments carried out by Dr. Letheby on the gas manufactured by this process showed that it afforded, on an average, a light equivalent to 23 05 candles; though the sulphurous and ammoniacal impurities were relatively considerable.

The Gas-Light Association of the U. S.—We learn through Professor Henry Wurtz, editor of *Am. Gas-Light Journal*, of the recent organization of a National Association of the American Gas Fraternity.

The need of such a union for promoting the development of this important interest, in its scientific and commercial aspects, has long been felt, and earnest and repeated efforts have been put forth to bring about the important movement, of which it is our pleasure to

announce the inauguration. It is to be wished that it may prove as beneficial in its working to all interested as the numerous kindred associations abroad, and it is to be hoped will mark a new era in the history of gas in America.

The following gentlemen have been elected officers of the new Association:—President, Chas. Roome, N. Y., president Manhattan Gas Co.; 1st Vice-President, P. E. Demill, of Michigan; 2d Vice-President, W. H. Price, of Ohio; 3d Vice-President, Thos. R. Brown, Pa., Eng. Philada. Gas Works; Secretary, Prof. Henry Wurtz, of New York; Treasurer, J. W. Smith, of New York.

A Mysterious Explosion.—Some weeks ago an explosion, attended with serious consequences, occurred at Rising Sun, a suburb of Philadelphia. The circumstances of the case are of so unusual a nature as to be deemed worthy of insertion in the JOURNAL. A well, some twenty-five feet in depth, situated on the premises in question, was to be enclosed to be made the receptacle of a food-preserver. To insure perfect safety for the carpenter who was employed for the work, a rope with a blanket attached, was lowered into the well and vigorously shaken up and down. Upon this, a lighted lantern was lowered, when an explosion followed, inflicting serious personal injury to those about the well; while from the strong sheet of flame ejected, the rafters and roof of the shed enclosing the well were scorched and blackened for a considerable space around.

The cause of this unlooked-for accident remained for a time unexplained, though various theories for its occurrence were advanced. An invitation extended to the editor of the Journal to visit the scene of the occurrence, was accepted and made.

It was found upon examination, that the premises were lighted by a gasolene air-blowing machine. The tank for holding the gasolene was placed in a pit especially dug for the purpose, some eight feet in depth, and located some fifteen yards from the well in which the explosion had occurred. On general grounds, the probabilities pointed to this as the source of the mischief; a suspicion which was subsequently fully verified. A descent into the pit and an examination of the tank, disclosed the fact that it was and probably had been for some time slowly leaking. It was almost certain, therefore, that the oil had found its way through the cement floor of the pit, which was imperfect in some places, and had slowly filtered with the natural lead of the water through the porous earth into the well. Here, by being undisturbed, its vapor had slowly diffused into the air of the well,

forming an explosive mixture, which, on the introduction of the lighted lantern, especially after the intimate mixture of oil vapor and air had been facilitated by the agitation with the blanket, mentioned at the outset, had caused the violent and unlooked for explosion.

Fortunately, an unlooked for circumstance afforded an opportunity for demonstrating the accuracy of this inference.

To drain off the water which in wet seasons would accumulate in the gasolene pit, connection had been established by means of a pipe between the bottom of the pit and another well situated in a direction opposite to that in which the explosion had happened. This had been abandoned for some time, and was boarded over and covered with a layer of earth. On request, the well was opened, and upon the introduction of a lighted paper, there followed a roaring explosion.

The incident here narrated, though in itself quite unimportant, yet receives interest, as another indication of the very insidious and unlooked for dangers with which one may be surrounded, in employing gasolene or similar inflammable substances in quantity in the household. Curiously enough, too, not the slightest suspicion as to the true cause of the accident was entertained by the parties interested.

American Gas Wells.—It may be of interest to note the fact that extensive utilization is made in various regions of our country, of the inflammable gases which issue from the earth, in certain localities, in almost incredible volume. From a recent article by Prof. J. S. Newberry, we learn that the gas which issues from the salt wells of the Kanawha Valley has been for years employed as a fuel in the evaporation of the brine.

The town of Fredonia, N. Y., has for more than forty years been fully or partially lighted by gas which issues from springs at that place. In numerous borings made for oil in the West, gas has been met with in abundance, and was regarded formerly as a useless and inconvenient product. Within the past few years however, the gas has been largely utilized, and borings have even been made with the express design of obtaining it. In some cases these gas wells have been highly productive, furnishing an abundance of material for heating and lighting in a most convenient and manageable form. As noteworthy occurrences in this connection, the article in question states that on the Upper Cumberland, in Kentucky, gas accumulates in such quantities beneath the strata of lower silurian limestone, that many hundred tons of rock and earth are sometimes blown out with

great violence. These explosions have received the local name of "gas volcanoes." In Ohio, gas escapes from nearly all the wells bored for oil in the oil-producing districts. One well, in Knox Co., of that State, has for five years continued to send forth a constant stream of gas, of such enormous volume that when ignited it forms a jet of flame three feet in diameter and fifteen feet long. Another neighboring well constantly ejects, at intervals of one minute, the water which fills it, and thus forms an intermittent fountain 120 feet in height. Another well, in West Bloomfield, N. Y., delivering, according to Prof. Wurtz, about 15 cubic feet per second, will probably shortly be utilized to supply, for industrial purposes, the city of Rochester, some twenty miles distant.

At Erie, Pa., there are now twenty-five wells in successful operation, most of which have been bored for the express purpose of obtaining gas.

For illuminating purposes this natural product seems to be much inferior to that furnished in cities and towns, ranging about 7 or 8 candles; its chief application has thus far been for heating purposes, for which it seems eminently qualified. Upon removing by simple means some of the ingredients which diminish its illuminating qualities (carbonic acid, &c.), its value a sa lighting agent is greatly increased.

The Commercial Production of Oxygen.—The following details of the process followed by the Oxyhydrogen Gas Company, of Buffalo, N. Y., in the production of oxygen on a commercial scale, may be of interest, though it is in general the same as that previously described in the "Journal," in reference to the process of M. Tessie du Mothay.

The material employed is called manganate of soda. Whether this definition of its constitution is accurate, from a chemical point of view, we are unable to assert. The treatment of the material is thus described: "The pulverized manganate of soda is introduced into iron retorts seven feet long, one foot wide and two deep (a cross section being an ellipse). It is here heated in a current of superheated steam. The steam passes through the mass and carries with it part of the oxygen. In ten minutes the current of steam is shut off and atmospheric air is blown in; the soda salt now re-absorbs or re-unites with the oxygen, and the nitrogen escapes. . . . Air is passed in for ten minutes, and then steam as before.

"From the retorts the gas passes to the condensers, which are like the usual upright cast-iron pipes used in all gas works. Here the steam is condensed, and it washes the gas; from these the gas passes to the scrubber, where all further impurities are washed out; it then passes to the holder."*

It seems that the process followed is not identical with the published description of the patent. Several modifications in details have been found necessary in practice. The manganate also appears not to work to perfection, since it has been found to lose its porosity and agglomerate after being for some time in use. It is found necessary, therefore, to re-charge the retorts after a time with fresh material. Experience indicates that, could the steam be supplied perfectly dry, this difficulty might be obviated.

What may be the ultimate success of the company must be left for time to decide. It is at present supplying consumers with hydrogen gas at the rate of $2·50 per M., and oxygen gas at the rate of $5·00 per M.

Artificial Alizarine.—The manufacture of the artificial alizarine—the coloring matter of the madder root—seems to be steadily progressing toward a practically commercial success. It is only about three years ago that the discovery of the method of its artificial production in the laboratory was hailed by the chemical world with a spirit of rejoicing as a fresh triumph for purely scientific research; while to-day it is offered in the market at prices below that demanded for the natural product, obtained from the madder. It is said that the cheapness of the artificial material is already creating distress amongst the growers of the root in those districts of continental Europe where its cultivation forms almost the sole dependence of its population, and the near future will, in all probability, by the steady growth of the production of the artificial material, add to the severity of the competition. Whether or not the result will finally be the extinction of the madder-growing industry, remains to be seen, though the probabilities point strongly in that direction. A Philadelphia industrial establishment has lately purchased a considerable quantity of the artificial alizarine, at a cost of twenty-five per cent. below that at which the natural product can be manufactured. The steady growth of the manufacture of the artificial product deserves wide-spread recognition, as one of the most important advances of which the technical chemistry of our times can boast.

* American Artisan.

Preservation of Wines.*—Prof. Neubauer has obtained such satisfactory results with Pasteur's process of heating wine up to 60° or 65° C., that the wine growers of Ahrweiler have put it into practice. Dr. Buhl has heated his wines for some years with the best results. It is claimed that this operation kills or destroys the yeast globules and whatever germs may be present, and does not at all injure the wine.

New Process for Purification of Iron and Steel.—A recent process of this tenor, patented by Mr. Thomas Shaw, a member of the Institute, consists in directing a jet of dry steam upon the molten iron as it runs from the cupola furnace. The floor upon which the iron falls is divided into four compartments. The iron falling farthest from the nozzle, will, it is declared, be soft wrought iron; that in the next compartment, cast steel; in the next, fine cast iron; and in the nearest one, ordinary cast iron.

Diamonds from the Gold Sands of California.—Prof. Benj. Silliman has lately communicated to the American Institute of Mining Engineers the information that he has detected, in appreciable quantity, the presence of microscopic diamonds in the sands of hydraulic washings in California, associated with zircons (hyacinth), topaz, quartz, chromic iron, etc. The occurrence of diamonds of some size in the sands from the gold washings of that State is stated to be not uncommon.

New Submarine Lamp.—An instrument of this kind has been designed by M. Pasteur, which is based upon the fact that the expired and vitiated air discharged by divers, still contains enough oxygen to support the flame of a petroleum lamp.†

Accordingly, he connects with the flexible escape pipe of a diver's helmet a suitable arrangement of lamp of this kind. The lamp may be carried in the hand of the diver or may be attached to any part of the person.

The flow of the escaping air from the helmet through the lamp gives a bright flame, enabling the diver to see in all directions; rendering the employment of the expensive and troublesome electric light no longer necessary.

A New Photometer.—M. Yvon has recently communicated to

* Ind. Blätter.

† Iron age.

the French Academy the plan of a photometer based on the perception of relief, which, though we have had no opportunity of testing its practicability, seems worthy of notice from its simplicity and novelty. The arrangement is described as follows:

Let there be two plain white surfaces placed at right angles to each other: e. g., fold a sheet of paper or a card in the middle, and place it upright on a table, so that the two halves form a right angle.

Let the observer now place himself a short distance off, so that his eye is in the prolongation of a line bisecting the angle formed by the halves of the sheet, and look at the edge through a tube which has been blackened in the inside. So long as the two surfaces are unequally illuminated he has a perception of relief; when, however, the two surfaces are equally illuminated he sees what appears to be a plane surface.

From this general description of the method of observation the reader will be able, without further direction, to arrange the position of the lights to be compared and other details of the measurement.

The St. Gothard Tunnel.—From foreign sources it is stated that the elaborate machinery for piercing the St. Gothard Tunnel is almost ready for service, when this important work will be advanced with rapidity.

The progress in the tunnel at the north side, at Goshen, up to Dec. 31st, was at the rate of only 0·30 metres per day, the heading here being driven into the hardest granite. At that date, the total length driven at this end was twenty metres, the number of men employed being 100.

At Airolo the rock met with is somewhat softer, and 102 metres had been tunnelled at the close of the year. At this end, also, the masonry is begun, and from 170 to 200 persons are employed.

It is designed to preserve specimens of every rock species and variety met with in the construction of the tunnel, of which 10 or 12 collections will be made, several sets of which will doubtless find their appropriate disposition in the cabinets of the Swiss and Italian technical schools, where their value will be best appreciated.

The U. S. Naval Observatory.—The splendid telescope designed for the National Observatory at Washington will, in all probability, soon be erected and in use. The work upon the new tower and dome intended for its reception is being rapidly brought to completion.

The object-glass—the largest in the world, 26½ in. diameter and 32 feet focal length—is now finished and ready for the instrument.

The cost of the new instrument, with the necessary machinery, will be about $30,000, and that of the tower and dome erected to receive it about $15,000.

The instrument at present in use at the Observatory has an object-glass of but 9 inches diameter, so that the Professors of the Institution may be congratulated upon the splendid acquisition to its efficiency, in prospect.

If to this we add the list of new apparatus already acquired or in process of construction for the Observatory, for the observation of the coming transit of Venus, the Institution will shortly be as well or perhaps better equipped than any other of its kind in the world.

Economic Limits of Steam Expansion.—An interesting discussion upon the limit to the expansion of steam took place recently before the Manchester Scientific and Mechanical Society. The paper originating the discussion was read by Mr. McNaught, who in the course of his subject declared that he had long since reached the conclusion that the expansion of steam can be carried too far. When steam had been expanded to six times its volume, its maximum economic effect had been attained. The writer contended that no economy was to be attained beyond this point, simply because the back pressure then not only lost its value, but operated against any economical result. If more expansion was desired the piston would have to be enlarged, and that would increase the prejudicial operation of the back pressure.

In the discussion which followed, many gentlemen present took sides against the views above expressed.

Russian Sheet Iron.—The Am. Manufacturer states the fact that Messrs. Rogers and Burchfield, of Pittsburg, a few days ago, made their first consignment of Russian sheet iron to Liverpool, England. It appears from the statement of the makers, that it can be manufactured here and exported cheaper than it can be imported from Russia to England. Their present capacity for producing this important specialty is given at two tons per day, which may be largely increased.

Engineering College in Japan.—The Japanese government has recently given another significant indication of the rapid strides

which are being made in that remarkable country, in what relates to the acquisition of modern scientific knowledge, by the foundation at Jeddo of a College of Engineering, in which natives of the country are to be instructed in technology and practical engineering. Prof. Henry Dyer, formerly of Glasgow, Scotland, has been appointed the director of the new institution.

Olefiant Gas and Ozone.—An interesting observation by M. Houzeau, is the fact that a mixture of olefiant gas (heavy carburetted hydrogen) with ozone, detonates violently without the aid of either heat, light or electricity, it being simply necessary that the ozone should be present in sufficiently concentrated form.

The experiment may be repeated in public without danger, by passing very slowly a current of olefiant gas (obtained by the reaction of sulphuric acid and alcohol) through a rather wide tube, and at the same time permitting a slow current of ozone, direct from the ozonizer, to traverse a narrow tube, penetrating about one centimeter within that filled with the ethylene.

Under these circumstances, each portion of the ozone, as it mixes with the heavy carburetted hydrogen, produces a sharp detonation.

In general, the vivid combustion of the ethylene is preceded by white vapors, produced by the slow oxidation of the gas.

Testing Strength of Materials.—It is the intention of Prof. Thurston to continue the valuable experiments upon the strength of materials, with the apparatus lately described in the Journal, for automatically registering its determinations.

The work to be undertaken will be upon the metals and their alloys. Prof. Thurston therefore desires to obtain for this purpose samples of standard brands of irons, and of useful and interesting alloys, for test.

The results will all be made public. During the absence of Prof. Thurston, who sails shortly for Vienna as a member of the United States Scientific Commission, Mr. Bachman will receive and take charge of samples, which may be sent to the Steven's Institute.

Franklin Institute.

Proceedings of the Stated Meeting, February 19, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held February 12th, 1873, the following donations to the Library had been announced:

Report on the North Sea Canal of Holland, and on the Improvements of Navigation from Rotterdam to the Sea. By Major General Barnard. From Simon Stevens, Esq.

Public Works of the United States of America in 1870. From the Minister of Public Works. Paris, France.

Comptes Rendus, Sept. 9th to Nov. 18th, 1872. From the Academy of Sciences, Paris, France.

Annual Report of the Chief Signal Officer to the Secretary of War, for the year 1872. From the Chief Signal Officer.

Journal of the Society of Arts, of London, for November, 1872. From the Society.

Journal Royal Geographical Society, Vol. 41st, with a classified Catalogue of their Library. From the Society.

Quarterly Weather Reports of the Meteorological Office. From the Meteorological Committee, London.

Annals Des Pontes et Chaussees, for September and October, 1872. From the Administration of Bridges and Roads, Paris, and the Ninth Census.

The Statistics of the Population of the United States for 1870. From the U. S. Census Bureau.

The Committee on the Horse Power of Steam Boilers reported progress and was continued.

The Committee on Conflagrations made a lengthy report, through its chairman, Mr. J. B. Burleigh, who in conclusion of his remarks, called attention to a communication on the subject, at the request of the committee, by the Secretary. The communication was thereupon read. The reports referred to will be found published in the Journal of the Institute for April, 1873.

The President next announced a paper by Mr. G. P. Hachenberg,

on the subject of Musical Telegraphy, in which he explained at length a system of electrical music, and suggested a plan for a large Music Hall for the proper exhibition of the system, in connection with the coming Centennial Exhibition in 1876.

Mr. Wm. B. Le Van next presented a paper on the late Boiler Explosion at Conshohocken, which detailed the history of the exploded boiler, and the cause and effects of its explosion. The paper elicited some discussion, and is published in the Journal of the Institute for March, 1878.

Mr. Murphy next offered a paper on the Ice Gorge in the Schuylkill.

The Secretary then offered a short report on Novelties in Science and the Mechanic Arts.

Under the head of New Business, Mr. Orr offered the following:

Resolved, That the "Franklin Institute" cordially approves of a thorough Geological Survey of the State of Pennsylvania, as recommended by Prof. Lesley, in his letter to Governor Hartranft, and respectfully ask of our Legislature the proper legislation to give prompt and full effect to the same.

The resolution was adopted.

The same gentleman offered the report of the Optical Section of the Institute for the year just passed, which was accepted.

Mr. Le Van moved that a committee be appointed to fix on a formula for the Factor of Safety for the carrying of Steam Pressure, to be known as the "Franklin Institute" formula. The mover asked that, in the event of the passage of the motion, Mr. Robert Briggs be appointed as the chairman of the proposed committee. The motion was carried. The President stated that he would announce the committee at the March meeting of the Institute.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*

Civil and Mechanical Engineering.

EXTRACT FROM REPORT OF CHIEF ENGINEER JOHN P. CULVER, OF THE BUREAU OF ENGINEERING AND SURVEYING OF JERSEY CITY.

At the time the Board of Public Works assumed control of the water works, the foundations for building contracted for by the Water Commissioners were nearly completed, but at my request the prosecution of the work was suspended, that the advisability of substituting duplex engines for the intended Cornish engines might be considered.

On the 5th of June, 1871, the following report was made by our Consulting Mechanical Engineer and myself:

Report on Duplex Engine.—"We submit herewith our report relative to the advisability of substituting the Worthington Duplex engine for Cornish engines, for the high service supply of this city.

"Although satisfied, from knowledge previously obtained, and the comparison of statistics concerning the subject, that for the use intended in this case there was but little question concerning which engine would be preferable, we yet deemed it best to make a personal investigation, and from an actual inspection corroborate such data as have from time to time been furnished concerning the working of the Duplex engine.

"We visited the Mystic water works at Charlestown, Massachusetts, and the Fairmount water works at Philadelphia, and at both places were treated with the utmost courtesy and everything done to facilitate our obtaining desired knowledge. While availing ourselves of the information tendered by those having supervision of the works, we have also examined the mechanism of the engines, and consulted the operative engineers in charge.

"At Charlestown, Edward Lawrence, Esq., President of the works, informed me that the Duplex was adopted after a full and careful examination of the claims of the Cornish and other forms of pumping engines, and after using the Duplex for six years he is so well satisfied concerning its superiority that he has recently ordered a third engine of the same pattern but of larger dimensions, for the Mystic works.

"The two engines now in use have a capacity of five million gallons each per diem.

"The new engine is to have a capacity of eight million gallons per diem.

"As an evidence of the care with which the engines had been constructed, Mr. Lawrence informed us that the cost of repairs for the six years had been less than one hundred dollars; we were shown one of the pump valves which had been in use four years and was still in good condition.

"The duty done in raising water to an elevation of one hundred feet for each one hundred pounds of fuel consumed, was considered by Mr. Lawrence as being fully equal to the best work performed by the Cornish engines under the most favorable circumstances.

"Mr. Graff, the Chief Engineer of the Fairmount water works as well as the entire water works of Philadelphia, a gentleman whose reputation is national, and whose opinion is entitled to the most respectful consideration, informed us that the performance of his best Cornish engine had been equalled by his Duplex engines at Belmont, and the fact that he had ordered three additional Duplex engines is strong evidence of his unqualified preference.

"He says that the Duplex has given him no trouble, the costs for repairs have been so trifling as scarcely to deserve mention, and that their immunity from accidents, due to their mechanical construction, is such that he is relieved from the anxiety and care inseparably connected with the working of Cornish engines.

"The Cornish engine has the sanction of time, and the respectability that naturally clings to established usage, but in this progressive age, rife with the spirit of improvement, its past usefulness cannot guarantee its continuance, nor be used as an argument against the adoption of other engines, if the crucial test of actual duty proves their superiority.

"The Cornish engine, one of the first forms of steam engines, is only properly adapted to the peculiar service in which it originated—the lifting of water from deep mines.

"As the engine was placed on the surface and the pumps deep in the bowels of the earth, long and heavy rods were essential for the-r connection.

"Power was naturally employed in lifting the weights, and their gravity in falling raised the water to the desired elevation.

"In such service any intermitted action was of but little consequence, and economy in fuel a desideratum.

"The establishment of a system of annual reports excited emula

lation which resulted in the designs of the engines being improved, and they gradually assumed the perfection at last attained.

"Their high duty finally became celebrated, and in after years, as the demands for pumping engines for water works developed, it was natural that the Cornish engine should be selected, the more particularly as the service was in many respects similar; the water being obtained from pits or shafts sunk through the chalk formations, until the apparently inexhaustible reservoir that underlies so much of England was reached.

"Once used as pumping engines for the water works of towns, modifications adapted them to the conditions in which we are now using them, and so far as economical use of fuel is concerned, they still, under favorable conditions, maintain their reputation, and although equalled, have never been excelled.

"Experience tends to show, however, that in many other respects as essential as economy they are inferior.

"The efficiency of a pumping service of a city underlies the prosperity, comfort, safety, and health of its inhabitants, and such efficiency is dependent to a great extent on the durability of the engines and their freedom from accidents, and on these points the Cornish engines are defective.

"They are in fact the most precarious form of engine known, requiring not only the utmost skill upon the part of the attendants, but are liable to accidents against which it appears impossible to guard, and the immunity we enjoy is no evidence that the works may not be disabled at any time; in proof of which it may be said that there is scarcely a Cornish engine in the country but what has been subject to dislocation and fractures, more or less extensive; which, being due to their form and action, scarcely admits of a remedy.

"The intermittent action of the Cornish engine is a serious argument against its adoption, entailing as it does the necessity for a stand-pipe, a contrivance whose objectionable features do not appear to require much comment, as we have so lately realized the danger incident to such a device, and are about to experience the cost of its maintenance in the construction of the tower at Belleville.

"An immense and weighty column of water in the stand-pipe alternates from a state of comparative rest to one of motion at every stroke of the pump, accompanied with very great and irregular strains upon the pump and contiguous valve chambers and pipes, which when augmented by a slight irregularity in the movements of

the valves (liable to occur from accidental causes), become so percussive as to cause serious and disastrous breaks.

"Various attempts have been made to construct new forms of engines in place of the Cornish; notably, the Hartford Cam engine, the Shield engine at Cincinnati, and the so-called Double-Action Cornish engine at Brooklyn, but none of them met with such success as to warrant their introduction, and we believe they have not been duplicated.

"A failure of considerable magnitude was also experienced at Detroit.

"The Worthington Duplex appears to be the engine destined to supplant the Cornish, and from the date of its introduction its reputation has grown and increased, until now its superiority is generally acknowledged by those most competent to decide.

"Seventeen years ago three Worthington engines were put up at Savannah; others of the same kind were erected at Cambridge in the year 1856, which, under careful trial, excelled every other engine in the country, our own at Belleville included.

"The Charlestown engines (being the first of the Duplex form) were erected in the year 1856, and their performance is asserted to be the best on record.

"At Cambridge they have recently put in a second engine of five million gallons capacity, also one at Salem of same size.

"One has been running at Harrisburg, Pa., almost constantly for ten years with almost no repairs.

"The Duplex is also to be used at Providence, Poughkeepsie, and other points.

"Two are running at the Newark water works, and several others could be enumerated if necessary, but we deem the foregoing sufficient to convince your honorable body that in using the Worthington Duplex engine you would neither be elucidating a vague theory nor testing an untried experiment.

"A noticeable feature and valuable characteristic of the Duplex engine is the noiseless way in which it performs its work; there is no concussion nor even an appreciable jar in the engine or its attachments; the piston acting directly on the water without the intervention of vast moving masses of metal, reduces, if it does not obviate, the danger of fracture or dislocation to which the Cornish engine is liable.

"The water-flow throughout the delivery main is so equable as to

scarcely disturb a sensitive gauge placed thereon, and the discharge into a reservoir is so uniform as to be without perceptible pulsation.

"The location of two Duplex engines on Bergen Hill will serve equally to render the supply for the upper service plenteous, and to fill the storage reservoir when it shall be constructed.

"Considering the foregoing, and that the present foundation of the new engine house can be utilized, while there will be no necessity for the erection of a stand-pipe and inclosing tower; and that the beam walls and second story of engine house will not be required, it is manifest that the simplest, safest, most durable and inexpensive engine should be selected.

"So that from motives of economy, believing that a great saving can be effected and the work done as well if not better than in any other manner, we would give our most emphatic preference to the Worthington Duplex engines, and recommend that they be used in the new works on Bergen Hill."

The recommendations contained in this report having been adopted, suitable changes were made in the plan of the building (which is now being completed), and contract entered into with Henry R. Worthington, Esq., for two of his Duplex engines, with boilers and attachments complete. One of these engines, as before mentioned, has been transferred to the pumping works on the Passaic river, the other is now being set up in the building on Bergen Hill.

The New Tin Fields.—The most favorable accounts continue to be received from the recently discovered tin fields in Queensland.

The discoveries have attracted large numbers to the region, and preparations for mining are being vigorously pushed. In one locality alone, over 1400 acres of claims have been taken up by different parties, who are making preparations for conducting sluicing operations upon a large scale, the water supply being abundant and every natural facility present.

As an indication of the ultimate value of these claims, it is stated that the ore yields 72 per cent. of metallic tin, and that all the prospects thus far obtained have averaged a quarter of a pound of ore to the dish.

It is proposed, by parties largely interested in the mines, to introduce Chinese labor for working them.

GAUGING OF RIVERS.

By Bvt. Brig. Gen. Henry L. Abbot, Major of Engineers.

(Continued from page 314.)

Tests and Extension of the Formulæ from the New Data.—This is not the place to explain in detail the principles upon which these formulæ are based; nor how to apply them to complex problems, such, for instance, as the rise in water surface which results from a given increase in discharge. These matters are fully discussed in the Physics and Hydraulics of the Mississippi. In this paper, I propose only to consider their practical applicability to water flowing in natural channels, as illustrated by actual measurements.

The observations available in deducing their constants—including not only all our own but also all published experiments of value—were thirty in number, and they are given in the following table, numbered from 50 to 79 inclusive. They are discussed with great care on pages 301—10 Physics and Hydraulics of the Mississippi.

The work of MM. Darcy and Bazin appeared four years after the publication of the Mississippi Report, but in a joint review of the two works M. Victor Fournié, Engineer of the Corps des Ponts et Chaussées, states that the authors were ignorant of the existence of the latter prior to the publication of their own. The new laws and formulæ announced have, therefore, received no discussion from M. Bazin; and his report must be studied, in order to determine what means it supplies for testing our conclusions. It is a work of high scientific merit and practical importance, treating of many branches of hydraulics which have no immediate connection with the gauging of rivers.

MM. Darcy and Bazin have removed one important error, which for three quarters of a century has encumbered science, viz., the law known as Coulomb's. This law avers that the friction of water upon the walls of its bed is independent of the material of which that bed is made. Dupuit—whose treatise on the Theory of Flowing Water, published in 1848, is a monument of scientific ability—doubts the truth of this law. Certain results, reported on page 318 of the Physics and Hydraulics of the Mississippi, suggested the same conclusion. M. Bazin has finally demonstrated this law to be false. He divides his experiments into four classes: those where his little canals were lined with very smooth materials, as polished cement, planed wood etc.; those lined with slightly rough materials, as cut stone, bricks planks, etc.; those quite rough, as rubble masonry; and, lastly, those

lined with earth. He proposes a formula, with different constants for each class; and shows conclusively that these differences are necessary to make experiment accord with theory.

He seems, however, to have overlooked one logical sequence of this new principle, viz., that the velocity at the perimeter, and not the mean velocity, must of necessity enter his equations. This necessity, which was theoretically established by M. Dupuit, in 1848; which was recognized in our formulæ; and which becomes doubly unavoidable since Coulomb's law is shown to be false—is rejected by M. Bazin. In fact, he simplifies instead of complicating the usual form of the equation for water flowing uniformly; no doubt because his investigations did not lead him to discover the law which governs the action of cohesion among the different particles of water, in transmitting the effect of the primitive resistance. Apart from the classification of channels, his formulæ are, therefore, theoretically no more exact than those of de Prony and other writers, and are only superior in practice because of his better data for determining the constants.

To his first three classes of channels our formulæ have no application, as was fully and repeatedly stated in the Physics and Hydraulics of the Mississippi. To some of his experiments in earthen channels they should apply, provided their constants were deduced with sufficient accuracy to include streams so very much smaller than any available in our investigations. I have, therefore, carefully examined these new data, applying to them the discrimination used in selecting observations from which to deduce our constants.

The Darcy and Bazin data for earthen beds comprise:

1. Observations upon the feeders Grosbois and Chazilly of the canal of Bourgogne. Series 37, 38, 41 and 49 were upon portions of these feeders where the bottom was of earth, but pebbly, except in the last, which was muddy. The only remaining series, 47, 48 and 50, were made (see pp. 454 and 455) where a few plants grew in the bed.

2. An experiment on the canal Marseille, which closely resembled a natural channel, and which was therefore an unexceptionable observation.

3. Dubuat's experiments on the Canal du Jard,—not applicable to a river formula, as is fully shown on page 306 Physics and Hydraulics of the Mississippi.

4. Dubuat's observations on the river Haine; two of which were

used in our investigations, and the other two shown to be inapplicable, on page 307.

5. The observations of Funk on the Weser, concerning which M. Bazin remarks: "It is to be noted that Funk has almost always adopted the same slope for an entire group of experiments, a circumstance which does not occur in a natural channel. The original data appear, according to Hagen, to have been corrected and co-ordinated so as to render uniform, slopes at first different." It is clear that such observations possess no value.

6. The experiments of Bruning on the branches of the Rhine. M. Bazin states, on the authority of Hagen, that these slopes were not measured; and that they either "were computed subsequently, so as to place the results in accord with existing formulæ, or were determined by a later leveling in 1797. Such data evidently are valueless.

7. Some old experiments of Bonati on the Po, and of the Roman school of Ponts et Chaussées on the Po and the Tiber. M. Bazin remarks "the value to be assigned to the slopes for these observations is not better determined." He does not report them in detail, and as M. de Prony's Recueil de Cinq Tables, from which he obtained them, is not at hand, I have been unable to make use of them.

8. A series of unpublished experiments on the Seine, executed at Paris in 1851 and 1852 under direction of M. Poiree, Ingenieur des Ponts et Chaussées. They were made with floats, and are the mean of many gaugings made at about the same stands of the river. M. Bazin calls them "good," as, no doubt, they are.

9. A series of experiments made on the Seine at Poissy, Triel and Meulan, in 1852 and 1853 under the direction of M. Emmery, Ingenieur des Ponts et Chaussées. Respecting these experiments, it is to be remarked that the water level varied during the observations. The mean amount was about 8 inches, the maximum being nearly 2 feet. With a river having a mean depth of only about 12 or 13 feet, it would seem that such oscillations—probably tidal—must have destroyed all precision in the measurement of slopes. Still, I have applied the formula to the data, although regarding them as of very doubtful accuracy.

10. A series of experiments on the Saone, in 1857–59, conducted, until his death, under the direction of M. Leveille, Ingenieur en chef des Ponts et Chaussées. This series of ten observations is stamped with the evident inaccuracy of an unvarying slope, while the river

increases its discharge twenty-two hundred per cent., and its mean radius, five hundred per cent. (from 3 to about 16 feet). It is certain that they can possess no value for testing river formulæ, and I have therefore rejected them.

In fine, then, I find that the work of MM. Darcy and Bazin furnishes 49 measurements admissible for testing river formulæ; although the nine upon the lower Seine are of doubtful merit. The others are unquestionably of high value.

The contributions of M. Grebenau consist of six measurements on small natural streams, made with great care by himself, and fully reported; of five gaugings of Bavarian rivers made in 1856–57; of three recent gaugings of the Rhine by Baden engineers; and of a measurement on a small canal by M. Strauss. His thorough manner of discussing his data leaves nothing to be added.

To these 64 observations I have applied our formula; and, to complete the discussion, have added our own data and applied to them the new formulæ of MM. Darcy and Bazin, and M. Hagen. The following table exhibits the results in detail, numbered as in the original reports. The first 49 observations are those from the work of MM. Darcy and Bazin. The next 30 are the data from the Physics and Hydraulics of the Mississippi. The next 15 are from the large work, or from a more recent pamphlet by M. Grebenau. The next two are from a forthcoming report, by General G. K. Warren, upon his late surveys of the Upper Mississippi; the former was made at St. Paul, and the latter at Fort Snelling. The last two are from the report of Mr. Thos. C. Clarke, Chief Engineer of the Railway Bridge at Quincy, Ills. His measurements were carefully made at that city in 1866–67; and, as nearly as practicable, at low water and high water stages, the difference in level being 12·4 feet.

In the table, the discrepancies, applied with their signs to the computed velocities, reduce them to those observed.

A cursory inspection of this table makes it evident that our formula accords in a remarkable manner with measurements upon channels varying from the dimensions of the Mississippi river to those of diminutive canal feeders, and comprising a range of slopes from 0·000 004 to 0·009, while the formulæ of MM. Darcy and Bazin and M. Hagen have a more limited application. They are improvements upon the old formulæ for large rivers, as appears from the following figures, which denote the sums of the discrepancies in mean velocity for the 30 observations reported in the Physics and Hydraulics of the Mississippi, and for which the sum of the mean

velocities is 115·5 feet. M. Hagen had access to these observations in deducing his constants.

Measurements upon Natural Channels, with Tests of Formulæ for Mean Velocity.

No.	Stream.	Original.		Cross Section.				Slope.	Observed Mean Velocity.	Discrepancy.		
		No.	Series.	Area.	Width.	Wetted Perimeter.	Mean Radius.			D. B. Formula.	Hagen Formula.	H. V. Formula.
				sq. ft.	ft.	ft.	ft.		ft.	ft.	ft.	ft.
1	Feeder Chazilly	1	37	9·5		9·9	0·96	0·000 792	1·234	—0·062	—0·072	—0·284
2		2		14·9		12·3	1·21	0·000 808	1·667	+0·067	+0·193	—0·062
3		3		19·4		13·8	1·41	0·000 858	1·815	—0·091	+0·208	—0·097
4		4		22·9		14·7	1·56	0·000 842	1.998	—0·060	+0·314	—0·013
5		1	38	9·3		9·7	0·96	0·000 957	1·244	—0·187	—0·106	—0·351
6		2		14·1		11·9	1·18	0·000 929	1·703	0·000	+0·213	—0·071
7		3		18·8		13·3	1·41	0·000 993	1.798	—0·252	+0·152	—0·184
8		4		22·2		14·4	1·54	0·000 986	1·959	—0·255	+0·244	—0·123
9		1	41	11 3		10·8	1·04	0·000 445	0 962	—0·087	—0·275	—0·400
10		2		18·1		13·1	1·38	0·000 450	1·296	—0·091	—0·132	—0·294
11		3		22·9		14·6	1·57	0·000 455	1·401	—0·112	—0·125	—0·312
12		4		27·2		15·9	1·71	0·000 441	1·510	—0·106	—0 074	—0·277
13	Feeder Grosbois	1	47	11·8		10·8	1·09	0·000 464	0·820	—0·295	—0·455	—0·589
14		2		17·2		12·5	1·38	0 000 450	1·326	—0·027	—0·102	—0·266
15		3		23·0		14·1	1·63	0·000 479	1·434	—0·172	—0·134	—0·337
16		4		26 8		15·7	1·71	0 000 493	1·683	—0·017	+0·070	—0·153
17		1	48	10·1		10·2	0·98	0·000 555	0·984	—0·157	—0·262	—0 415
18		2		15·4		11·8	1·30	0·000 555	1·480	+0·059	+0·045	—0·148
19		3		20·9		13·4	1 56	0·000 525	1·575	—0·047	+0·018	—0·199
20		4		25·9		14·1	1·71	0·000 515	1·746	0·000	+0·122	+0·037
21		1	49	10·9		11·4	0·96	0·000 250	0·886	+0·155	—0·194	—0·227
22		2		17·1		12·9	1·32	0·000 275	1·336	+0·321	+0·050	—0·026

22	.....	2		17·1		12·9	1·32	0·000 275	1·336	+0·321	+0·050	—0·026
23	.....	3		24·2		15·5	1·57	0·000 246	1·362	+0·245	—0·015	—0·092
24	.....	4		30·8		17·3	1·78	0·000 275	1·467	+0·148	—0 027	—0·136
25	.....	1	50	11·8		11·3	1·05	0·000 310	0·817	—0·065	—0·353	—0·422
26	.....	2		18·0		12·7	1·42	0·000 290	1·260	+0·151	—0·086	—0·175
27	.....	3		25·4		15·4	1·69	0·000 330	1·296	—0·052	—0·204	—0·319
28	.....	4		32·0		17 3	1·85	0·000 330	1·411	—0·085	—0·157	—0·310
29	Canal Marseille.....	7	1	66		23	2 9	0·000 430	2·536	+0·130	+0·483	+0·102
30	Seine at Paris.....	1		1 978		349	5·7	0·000 127	2·094	—0·126	—0·256	—0·371
31	.....	2		2 570		363	7·1	0·000 133	2·264	—0·385	—0·379	—0·406
32	.....	3		3 176		377	8·4	0·000 135	2·418	—0·580	—0·464	—0·680
33	.....	4		3 692		390	9·5	0 000 140	3·370	+0·076	+0·287	+0·039
34	.....	5		4 421		405	10·9	0·000 140	3·741	+0·132	+0 438	+0·150
35	.....	6		5 108		419	12·2	0·000 140	3·816	—0·053	+0·322	+0 009
36	.....	7		6 372		439	14·5	0·000 140	4·232	—0·085	+0·423	+0·058
37	.....	8		6 929		461	15·0	0·000 140	4·512	+0·110	+0·638	+0·256
38	.....	9		8 034		504	15·9	0·000 172	4·682	—0·375	+0·554	+0·055
39	.....	10		8 668		516	16·8	0·000 131	4·800	+0·240	+0·745	+0 360
40	.....	11		9 522		518	18·4	0·000 103	4·689	+0·427	+0·612	+0·321
41	Seine (Meulan).....	1		5 982		842	7·1	0·000 090	2·310	+0·140	—0·166	—0·234
42	.....	2		6 488		845	7·7	0·000 087	2·313	+0·046	—0·251	—0·314
43	Seine (Triel).....	3		5 640		502	11·2	0·000 057	2 363	+0·024	—0 519	—0·527
44	.....	4		6 375		513	12·4	0·000 060	2·359	—0·212	—0·700	—0·728
45	Seine (Poissy).....	5		7 475		551	13·6	0·000 050	2·372	—0·095	—0·735	—0·711
46	.....	6		7 952		560	14·2	0·000 054	2·595	—0·052	—0·621	—0·634
47	.....	7		8 996		567	15·9	0·000 062	2·911	—0·116	—0 571	—0·638
48	.....	8		9 733		578	16·8	0·000 067	3·101	—0·155	—0·525	—0·639
49	.....	9		10 400		582	17·8	0·000 075	3·330	—0·233	—0 483	—0·634
50	Mississippi R.....	1		193 968	2 653	2 693	72·9	0·000 020 5	5·929	+1·882	—0·235	+0·038
51	.....	2		195 349	2 656	2 696	72·4	0 000 017 1	5·887	+2·177	—0·109	+0·243
52	.....	3		180 968	2 421	2 461	73·6	0·000 003 4	4·034	+2 363	—0·584	+0·259
53	.....	4		183 663	2 429	2 469	74·4	0·000 003 8	3·977	+2·196	—0·753	+0·066

Measurements upon Natural Channels, with Tests of Formulæ for Mean Velocity—(Continued).

No.	Stream.	Original. No.	Original. Series.	Cross Section. Areas.	Cross Section. Width.	Cross Section. Wetted Perimeter.	Cross Section. Mean Radius.	Slope.	Observed Mean Velocity.	Discrepancy. D. B. Formula.	Discrepancy. Hagen Formula.	Discrepancy. A. H. Formula.
				sq. ft.	ft.	ft.	ft.		ft.	ft.	ft.	ft.
54	.....	5		148 042	2 214	2 247	65·9	0·000 068 0	6·957	—0·087	—0·243	—0 809
55	.....	6		178 137	2 729	2 779	64·1	0·000 063 8	6·949	+0·239	—0·076	—0·460
56	.....	7		179 502	2 732	2 782	64·5	0·000 043 6	6·825	+1·255	+0·211	+0·071
57	.....	8		78 828	2 507	2 530	31.2	0·000 022 3	3·523	+0 842	—0·591	—0·397
58	.....	9		134 942	2 556	2 589	52·1	0·000 030 3	5·558	+1·418	—0·037	+0·043
59	.....	10		150 354	2 580	2 621	57·4	0·000 048 1	6·319	+0·824	—0·024	—0·198
60	B. Plaquemine.....	11		5 560	292	303	18·3	0·000 206 4	5·198	—0·824	+0·633	—0·045
61	.....	12		4 259	268	278	15·3	0·000 1437	3 959	—0·553	+0·029	—0·387
62	B. La Fourche.....	13		3 738	223	238	15·7	0·000 044 7	3·076	+0·523	—0·201	—0·207
63	.....	14		3 025	223	232	13·0	0·000 037 3	2·843	+0·761	—0·050	+0·021
64	.....	15		2 957	223	231	12·8	0·000 036 6	2·807	+0·769	—0·055	+0 030
65	.....	16		2 868	223	230	15·7	0·000 043 8	2·789	+0·261	—0·476	—0·077
66	C. and O. C. feeder.....	17		121	23	32·7	3·7	0·000 698 5	3·032	—0·758	+0·517	—0 071
67	.....	18		119	23	32·5	3·7	0·000 698 5	2·723	—1·037	+0·208	—0·359
68	Ohio River.....	19		7 218	1 073	1 074	6·7	0·000 693 3	2·515	+0·378	+0·095	+0·030
69	River Haine.....	20		248·5	48	50·5	4·9	0·000 165 3	2·495	+0·215	+0·218	+0·025
70	.....	21		306·4	50·5	53·4	5·7	0·000 155 9	2·558	+0·200	+0·127	—0·088
71	Canal.....	22		50	18	20·6	2·4	0·000 063 1	1·134	+0·299	—0·223	—0·196
72	River Rhine.....	23		19 135	1 155	1 163	16·5	0 000 097 7	3·575	—0 308	—0·252	—0·481
73	.....	24		6 304	557	563	11·2	0·000 099 9	3·277	+0·181	+0·112	—0·054
74	River Waal.....	25		14 782	1 328	1 334	11·1	0·000 104 4	3·165	+0·019	—0·608	—0·181
75	Rhine.....	26		5 341	700	704	7·6	0·000 117 4	2·917	+0·314	+0 239	+0·097
76	Yssel.....	27		1 930	321	324	5·9	0·000 116 6	2·773	+0·578	+0·416	+0·299
77	Tiber.....	28		2 355	243	249	9·4	0 000 130 6	3 413	+0·236	+0·382	+0·138
78	Neva.....	29		43 461	1 218	1 227	35·4	0·000 013 9	3·230	+0·957	—20	+0·497
79	Great Nevka.....	30		15 554	881	893	17·4	0·000 014 9	2·049	+ 0 482	+ 0·824	—0.519

79	Great Nevka	30	15 554	881	893	17·4	0·000 014 9	2·049	+ 0 482	+ 0·824	—0.519
80	River Schwarza	1	46·7	56·6	58·3	0·80	0 009 000	2·528	—1·186	+0·737	—0·106
81	.....	2	52·3	50·8	52·9	0·99	0·005 200	2·544	—0·880	+0·726	—0·019
82	Hockenbach, I—II		10·5	11·1	12·0	0·87	0 000 778 3	1·440	+ 0·263	+0·198	—0·022
83	" II—III		10·3	11·0	11·8	0·88	0·000 796 6	1·463	+ 0·259	+0·209	+0·020
84	Speyerbach		30 2	16·1	19·7	1·54	0·000 466 6	1·814	+ 0·297	+0·300	+0·044
85	Hübengraben		3·8	4·8	6·4	0·59	0·001 300 0	1·424	+ 0·360	+0·310	—0·002
86	Salzach	1	4 005·6	375·9	377·8	7·00	0·000 360 0	4·118	—0·197	+1·020	—0·376
87	Saalach	2	86·9	60·4	61·2	1·38	0·001 035 7	2·155	+ 0·125	+ 0·515	+0·144
88	"	3	96·7	71·3	71·8	1·34	0·001 136 4	1·970	—0·127	+0·327	—0·044
89	Isar	5	300 1	153·7	161·6	1·85	0·002 500 0	3·997	—0·108	+1·797	+0·990
90	"	6	1 063·4	172·2	176·0	6·04	0·002 500 0	7·212	—3·054	+3·237	+1·717
91	Rhine	1	4 650·1	590·5	606·3	7·67	0·001 250 0	4·921	—1·761	+0·933	—0·315
92	"	2	13 725·5	590·5	633·8	21·65	0·001 000 0	8·858	—5·745	+2·399	+0·185
93	"	3	14 149·8	1 440 0	1 458·3	9·72	0·000 112 0	2·910	—0·086	—0·095	—0 276
94	Lauter Canal	4	56·4	29·6	31·0	1·82	0·000 664 0	2·106	+0·020	+0·356	+0·023
95	Upper Mississippi		5 010·1	462·0	467·0	10·85	0·000 028 9	1·509	—0·124	—1·024	—0·351
96	" "		3 441·0	773·0	778·0	4·42	0·000 222 7	2·611	+ 0·165	+0·339	+0 128
97	" "		15 911	1 607	1 612	9·87	0·000 074 34	2·941	+ 0·477	+0·113	—0·019
98	" "		51 610	3 160	3 172	16·27	0·000 074 34	3·898	+ 0·533	+0·267	+0·075
	Sum							282·183	45·861	38·224	25·463

Ellet's discrepancy, 45·4 feet; Dubuat's, 40·4 feet; Girard's, 37·4 Young's, 33·4 feet; Chezy-Young's, 32·9 feet; St. Venant's, 30·7 feet; Prony Eytelwein's, 29·5 feet; Prony-Wiesbach's, 28·8 feet; Chezy-Eytelwein's, 28·4 feet. Prony's two formulæ, 28·1 feet; Chezy-Downing's, 26·7 feet; Dupuit's, 25·1 feet; Darcy-Bazin's, 22·9 feet; Hagen's, 8·7 feet; Humphreys-Abbot's, 6·4 feet.

I have not taken the trouble to apply the older formulæ to the new data, and cannot therefore institute a similar comparison for them.

It has seemed to me advisable to closely scrutinize the above table, with a view to learn whether the new observations afford means of improving the form or constants of our formula. In such an investigation, it appears proper to classify the data according to the area of cross section, as this quantity is usually in natural channels the governing element which decides the character of the stream. When the discharge, and hence the area of cross section, is large, the depth is usually considerable and the slope gentle. With a less volume of water, the depth decreases and the slope increases. For very small sections, like those of canal feeders, the law of variation in the coefficients which take into account the action of cohesion is severely tested; and useful suggestions as to the laws governing these curves may be obtained. Guided by these views, I have prepared the following table to analyze the results shown in the last.

Preliminary Analysis of Data contained in preceding Table.

Area of Cross Section, varying between	No. of Obs.	Sum of observed Velocities.	Sum of computed Velocities.			Sum of Discrepancies.			Percentage of Discrepancies.		
			D. B. Formula.	Hagen Formula.	H. A. Formula.	D. B. Formula.	Hagen Formula.	H. A. Formula.	D. B. Formula.	Hagen Formula.	H. A. Formula.
Sq. ft.											
200 000 and 10 000	19	89·914	90·709	92·058	93·405	22·123	8·124	5·451	24·6	9·1	6·1
10 000 and 1 000	35	116·880	120·266	112·419	121·012	14 108	18·447	11·433	12·1	15·8	9·7
1 000 and 50	11	27·250	29·171	22·199	26·743	3·899	5·497	2·061	14·3	20·2	7·5
Less than 50	33	48·139	49·814	47·529	54·450	5·731	6·156	6·513	11·9	12·8	13·5
Total,	98	282·183	279·960	274·205	295·610	45·861	38·224	25·463	16·3	13·5	9·0

An examination of this table leads to interesting results. Our formula, which gives a less percentage of error than the others for all but the smallest of the four classes of natural streams, has its largest discrepancies in channels less than 50 feet in cross section.

With this class—which MM. Darcy and Bazin's excellent experiments permit for the first time to be closely analyzed,—our formula

gives a discrepancy of about 14 per cent., or nearly double that for larger streams; and, moreover, nearly all of the computed are in excess of the observed velocities. This is exactly what was anticipated when 100 square feet was fixed upon as a limit of applicability in respect to cross section. To render the reason clear, it will be needful to glance at some of the principles upon which our formula is based.

When water is moving uniformly, the accelerating are equal to the retarding forces. The former, in a straight channel, are measured by the product of the weight of the water into the sine of the slope of its surface. The latter arise from the joint action of two forces—adhesion to the bed and cohesion of the different particles of water to each other. The first is evidently the primary resistance, the second being rather a force which regulates the distribution of the effects of adhesion to the bed among the interior particles of the fluid mass. The resistances may therefore be expressed by the product of the area of the surface which experiences resistance to motion, multiplied by a function of the velocities at that surface—the particular form of this function remaining to be determined by experiment. The mean velocity is to be deduced from this mean exterior velocity by applying the laws governing the action of cohesion. A knowledge of these laws, therefore, becomes of primary importance—indeed is essential—in the solution of the problem.

The investigations upon the Mississippi river first revealed the laws governing the action of cohesion; and subsequent tests in Europe have established the accuracy of the conclusions at which we arrived. They may be briefly set forth as follows—or rather such of them as belong to this discussion:

In any vertical plane parallel to the current, there is a resistance to motion at the bottom and at the water surface. The latter is chiefly a transmitted resistance; probably arising from upward currents, occasioned by inequalities at the bottom, which retard the upper layer not only by shocks and boils in breaking, but also by actually transferring water moving at a slow rate near the bottom, to the surface. According to M. Bazin's views, the surface retardation is partly due to inequalities of movement occasioned by the relative absence of pressure, and it appears probable that this may be one cause of the phenomenon. Although, in the Mississippi Report, it is mathematically proved that this depression cannot be due to friction against the air, that work has been repeatedly misquoted by careless

writers as advocating this theory. Whatever the causes may be, it is a fact well established by observation that there is a resistance at the surface, and that its law of transmission is the same as that governing the change of velocity at different distances from the bottom. For framing a formula, it is, therefore, evident that surface and bottom must both be regarded as loci of the primary resistances to motion.

The law of transmission in a vertical plane is represented by the arc of a parabola whose axis is parallel to the surface, and usually from one to three tenths of the depth below it. The axis of this parabola moves up and down parallel to itself, as the relative resistances at the surface and bottom vary under the influence of winds or other extraneous forces. For the same depth and mean velocity, the curve itself is unvarying. As the depth or mean velocity is changed, the reciprocal of the parameter of the parabola varies in a manner indicated by the expression $\sqrt{b\,v}$, in which $b = \frac{1{\cdot}69}{\sqrt{D}+1{\cdot}5}$ The complete law for the change of velocity from surface to bottom in any vertical plane parallel to the current is, therefore, given in feet by the following equation, in which $V_{d'}$ denotes the maximum velocity and d' the depth below the surface at which it is located. V denotes the velocity at any depth d, the total depth being D.

$$V = V_{d'} - \sqrt{b\,v}\left(\frac{d-d'}{D}\right)^2$$

All the details of this parabolic law for the transmission of resistances through the fluid, were so clearly established for rivers by the investigations upon the Mississippi—not excepting even the effect of wind upon the mean vertical curve—that it does not seem necessary to thoroughly discuss the new data furnished by MM. Darcy and Bazin; especially in view of the following facts:

Their observations were confined to small artificial canals of various shapes, so narrow in proportion to their depth that the vertical and horizontal curves must have mutually affected each other to such a degree as to render very difficult a study of either of them separately. Moreover, owing to the shallow depths (2·16 feet being the maximum for the rectangular canals), the velocity was measured at a very limited number of points, usually only three or four, in each vertical plane. This not only prevents an exact determination of the curvature and depth of axis, but also the detection, through the law

of continuity, of errors of observation; which is the more to be regretted because such errors are very liable to occur, especially in the most characteristic parts of the curve near the bottom. In reference to some palpable discrepancies of this kind, M. Bazin remarks: "These anomalies, which only occur in the vicinity of the wetted perimeter, arise, because the smallest displacement of the instrument introduces a considerable error in estimating the velocity, when the extremity of the gauging tube is only separated about three quarters of an inch from the bed, near which the velocity always varies most rapidly." Still another cause of error in these observations has been suggested by M. Victor Fournié. The Darcy-Pitot tube, by which the velocities were measured, give the *instantaneous*, and not the *average continuous* velocity at each point. If it were possible to measure the velocity at all the points simultaneously, this might be no disadvantage; but as each point must be measured separately, and as the axis of the vertical curve is constantly oscillating under the influence of varying winds, thus occasioning the *pulsations* often reported by observers upon rivers, it is a serious cause of uncertainty in the observations. M. Fournié remarks: "It appears that the inadmissible irregularities of M. Bazin's curves of equal velocity may be thus explained. The perturbations may have masked the true laws."

An examination of the data—which were collected with great care and labor, and which are, undoubtedly, sufficiently exact for general purposes—leads to the conclusion that they afford strong confirmation of the truth of our parabolic theory, and make known the additional fact that the effect of the resistances at the sides of the channel is to depress in that vicinity the axes of the vertical parabolas—an effect which might naturally be anticipated in so narrow streams.

(To be continued.)

Steam on Common Roads.—The subject of introducing steam on city streets and common roads is a problem with us still in an unsettled state; while abroad the experiment seems to have been successfully undertaken.

Two main lines of tramway have recently been opened in Portugal, one of which leads from the capital in a northerly and north-easterly direction. The tramways are laid on the common road, the sharpest curves yet laid down having a radius of forty feet.

The traction wheels of the locomotives and the side wheels of the carriages run on longitudinal sleepers, the tires of the driving wheels projecting over the edges of the sleepers, so that slight sinking of the latter will not affect the wheels. The locomotives and cars have trucks, run on a central guide rail, the wheels being flanged on both sides.

HORSE-POWER OF BOILERS.

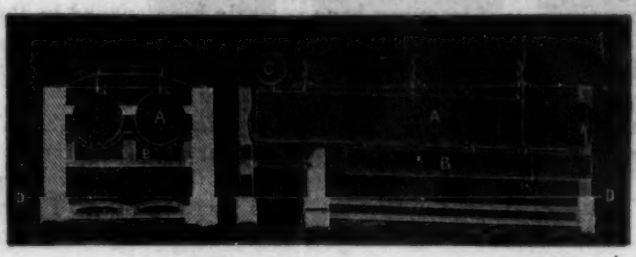
By W. Barnet LeVan, Engineer.

The term "horse-power," in its application to boilers, has heretofore been no less indefinite than the same term in its application to the steam engine. It has been customary to fix upon some unit of heating surface as the measure of the horse-power of a steam boiler. The boiler is supposed to furnish a definite amount of steam at the working pressure employed, this amount depending on the heating surface; and the utilization of all this steam, under the most favorable conditions, would thus furnish, through the medium of an engine, a certain amount of work or a certain horse-power. But experiments have shown that the same quantity of water evaporated by a boiler may produce widely different results in the engine, and the work done by the engine dependent upon the evaporation of the water may be changed very materially by the condition of the boiler, as well as by its form and construction. The boiler will do different quantities of work in the same engine, or in different engines under various conditions of working; these conditions being the pressure, the degree of expansion, and the speed of the piston. The horse-power of a boiler will therefore vary with the kind of steam engine, and with its condition.

It is, however, conceded that the amount of water evaporated into dry steam per hour under the ordinary conditions is the best measure of the capacity of the boiler. This amount has been heretofore generally stated at one cubic foot of water evaporated per hour to produce one horse-power.

I propose in this paper to show the horse-power of boilers, as shown by the experiment made at Belmont upon the boilers, engines and pumps of the Water Department, by a commission of gentlemen appointed by the Select and Common Councils of this city, of which Commission I had the honor of being a member.

BOILERS.

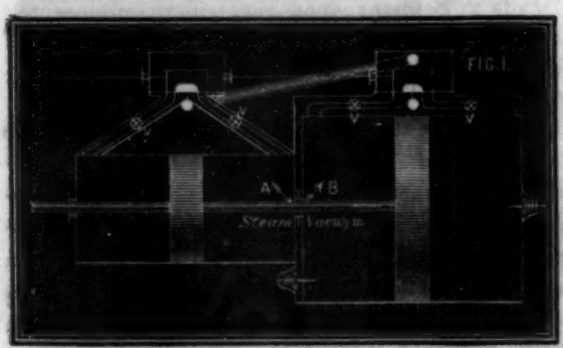


These experiments were made in May, 1872, with six Elephant or French boilers, of the following dimensions:

Total length in feet,	30·83
Diameter in inches,	54
Total length of mud drums in feet,	22
Diameter of mud drums in inches,	28
Number of mud drums,	2
Number of necks,	10
Length of necks in inches,	12
Diameter of necks in inches,	12
Length of grate bars in inches,	60
Width of grate-bars in inches,	52
Grate surface of one set in square feet,	43·33
Total grate surface of three sets in square feet,	130·
Total heating surface of one set of boilers in square feet,	508
Total heating surface of one set of mud drums in sq. feet,	616
Total heating surface of the three sets in square feet,	3372
Ratio of heating surface to grate surface,	26 : 1

DESCRIPTION OF THE DUPLEX PUMPING ENGINE.

The pumping engines are Worthington's Compound Duplex Engine, which consist of two high-pressure and two low-pressure cylinders. The initial pressure of the steam is used during the full stroke of the small cylinders, and the low pressure cylinders receive upon their increased piston area the steam discharged from the high-pressure ones. The high and low-pressure cylinders are placed in line, the former being in front of the latter, and the same piston-rod passing through both, and of such a length as to be attached to the plunger of the pump cylinder situated in advance of the high-pressure cylinder, so as to allow for the guides of the cross-head, and held in this position with the water cylinders in one direct line by four wrought-iron rods, forming an open space in which are placed two



Duplex Pumping Engine Cylinders.

single-acting air-pumps for each pair of steam cylinders, which are driven by rock shafts off the main piston-rod, and are in a convenient and accessible position beneath the guides. The steam cylinders and heads are steam-jacketed and thoroughly lagged. The steam slide-valves are carefully and simply balanced. The double-acting water-plungers are hollow cylinders with tight heads, their weight being thus nearly floated, and the water entering the numerous suction-valves below them, passes them in a nearly direct line into and through the force-valves above. The valves are rubber disks, backed with iron, working vertically on fixed spindles. The engines, being horizontal, are accessible for inspection and repairs. Each engine drives its plunger at a speed uniform throughout its stroke, during which it opens, by a rock-shaft and appropriate connections, the steam-valve of the other, and is obliged to pause at the end of its own stroke until its own steam-valve is opened by the motion of the other piston.

Indicator Diagram.
Taken from the rising main to reservoir.

The combined and reciprocal action of the two double-acting plungers is thus driven at unvarying piston speed by the combined pressures in the high and low-pressure steam cylinders (whose sum is a practically uniform quantity), which forces the water in a steady, quiet stream, as will be seen by the following indicator diagram, taken from the water main leading to reservoir.

The following are the principal dimensions of the cylinders, plungers, etc. :

DIMENSIONS.

Diameter of high-pressure cylinder in inches,	29
Diameter of low-pressure cylinder in inches,	50·25
Diameter of water-plungers in inches,	22·50
Diameter of piston-rod in inches,	4
Travel of pistons between cylinder heads in inches,	50
Diameter of air-pumps in inches,	20
Stroke of air-pumps in inches,	24
Number of air-pumps,	4
Number of high-pressure steam cylinders,	2
Number of low-pressure steam cylinders,	2
Number of water cylinders,	2
Number of inlet-valves in one cylinder,	16
Area of the 16 inlet-valves in square inches,	300
Number of outlet-valves in one cylinder,	16
Area of the 16 outlet valves in square inches,	300

THE WORK TO BE PERFORMED BY THE BOILERS.

The water in Fairmount dam to be lifted into the reservoir on George's Hill, situated in Fairmount Park.

The following are the height, length and diameter of main, namely:

Height to top of overflow pipe in feet,	208
Length of pumping main in feet,	4167
Diameter of pumping main in inches,	30

MANNER OF CONDUCTING THE EXPERIMENT, AND EXPERIMENTAL DATA AND RESULTS.

Previous to the test the pressure-gages were carefully compared with standard test-gages, and a certified statement of their variations obtained.

The coal scales were tested and sealed by the official sealer of weights and measures.

The evaporation was determined by measuring the water in an open tank previously to its being pumped into the boilers, its capacity being 20 cubic feet; 19 cubic feet was the usual charge at intervals of about ten minutes. A float and gage-rod was provided and marked in cubic feet by actual measurement from a box exactly 12 inches square, and filled 12 inches deep. The correctness of the manner of measurement was verified at the commencement of the trial. As often as emptied, it was refilled through a pipe from the hot-well of the engine. From the tank, the water was forced into the boilers by a

small steam pump. The measurement of feed water was constantly in charge of an assistant, and every separate charge of water to the boilers was entered into a book kept for the purpose.

The total amount of water supplied to the boilers was 5212 cubic feet. A leak discovered at the commencement in the feed-pipe, which was carefully measured for a given length of time, and thereby the quantity lost was accurately arrived at, amounted to 40 cubic feet (temperature 139° Fahr., weight 61·52 pounds per cubic foot), reduced the amount of water evaporated to 5172 cubic feet, or 318,181 pounds.

The coal consumed was excellent anthracite, a first quality of steam coal, giving the very small residuum of about 10 per centum.

The coal and ashes were carefully weighed, one or more assistants being on duty in the fire-room during the whole test, and having a constant supervision thereof.

During the test the pressure of the steam per gage and temperature of feed water, which for this purpose was drawn from a cock in the pipe a few feet before entering boiler, were taken every twenty minutes. These observations were made by not less than three persons at the same time, and their notes carefully compared and verified as the test progressed.

The experiment was commenced at precisely 4.40 P. M., on Wednesday, May 15th, and continued until Friday, May 17th, at 5 o'clock P. M., being of forty-eight hours and twenty minutes duration. At the commencement a large clean fire was upon the grates; the steam pressure in the boiler was 48 pounds per square inch above the atmosphere by an American Steam Gage Company's gage; and the height of the water in the boiler was carefully noted on glass gages attached to the front head of each boiler, with tubes extending through the brickwork. At the close of the experiment the steam was left at the same pressure in the boilers, and the fires in the same state, as nearly as could be estimated, as at the commencement. The water in the glass gages at the close of the test was 0·17 inch lower than at commencement. The boilers are therefore charged with coal sufficient to bring the deficiency of water (530 pounds) from 129°.59, the temperature of feed-water, to temperature of steam, at 48 pounds pressure, 295° Fahr., or 10 pounds of coal.

The following are the experimental data and results:

Duration of trial in hours, ...	48·33
Mean temperature of feed water in the tank, in degrees Fahr., ...	129°·59

Mean pressure of the steam in the boiler in pounds, per square inch, above the atmosphere,	48·85
Total weight of water evaporated from a temperature of 129°·59 in pounds,	318,181
Equivalent weight of water evaporated from and at 212° Fahr., and atmospheric pressure,	352,676
Total weight of anthracite coal consumed in pounds,	40,330
Total weight of ashes, clinker and fine coal withdrawn from ash-pit in pounds,	4,349
Per centum of ashes, clinker and fine coal,	10
Pounds of coal consumed per hour per sq. foot of grate surface,	6·09
Pounds of combustible consumed per hour per square foot of grate surface,	5·63
Pounds of water evaporated from a temperature of 129°.59 Fahr., by one pound of coal,	7·88
Pounds of water evaporated from a temperature of 212° Fahr. by one pound of coal,	8·74
Pounds of water evaporated from a temperature of 129°·59 Fahr. by one pound of combustible,	8·87
Pounds of water evaporated from a temperature of 212° Fahr. by one pound of combustible,	9·80

THE WEIR AT RESERVOIR.

The quantity of water discharged at the reservoir was measured over a weir, situated about 24 feet from the overflow of the delivery pipe in the flume, the crest of which was 8 inches lower than the mouth of said pipe, and the water flowing over it at an average depth of 9·2 inches. The sheet of water issuing from the pipe prior to the erection of the weir was about 4 inches deep. Considering all these conditions, the location of the weir was such that it did not obstruct

the flow of water from the pipe, neither was there such a fall from the pipe to the weir as to occasion any undue velocity in the flume. The flume was 7 feet wide; length of weir, 4 feet. The crest of weir was 5 feet above the bottom of flume, which sloped upwards from the weir towards the delivery-pipe.

To correct any inequalities in the velocity of the water approaching the weir, there were placed in the flume two fine gratings, *G*, about ten feet apart, equi-distant between the pipe and the weir, through which the water flowed before it reached the latter, and by this means an even, regular flow was obtained.

The depth of the water flowing over the weir was ascertained by a hook-gage, graduated to read to the one-thousandth of a foot, located about three feet up stream from the weir, supported by heavy timbers bolted to the masonry to avoid any danger of the gage moving out of its place after it was adjusted. The water in which the hook-gage was inserted was contained in a box communicating by pipes with the centre of a perforated pipe on the up-stream side of the weir extending nearly across the flume, in this way insuring the level of the water in the hook-gage box to be the same that would be due to the pressure of the water across the whole width of the weir.

The velocity of the water in the flume as it approached the weir was 27 of a foot per second. Mr. Francis's correction for this velocity would have added ·001 of a foot to the observed depth on the weir. The hook-gage when it recorded zero was accurately adjusted to be level with the crest of the weir at the commencement of the observations, by means of a graduated rule for that purpose.

The observations are recorded as running through 10 minutes, during which time two observations were made, and the average of these two was the depth recorded. The temperature of the water was noted at intervals, and in estimating the number of pounds of water pumped, the number of cubic feet of each recorded, temperature was computed.

THE WORK PERFORMED.

By the above observations there was delivered into the reservoir, namely:

1.	In twenty-four hours, in cubic feet,	747,047·45
2.	" " " "	743,622·01
3.	In twenty minutes " "	9,915·06
	Total,	1,500,584·52

The same converted into pounds, at the average temperatures noted amounted to

1.	Twenty-four hours, in pounds,	46,539,325
2.	" " "	46,328,629
3.	Twenty minutes, "	617,559
Total in forty-eight hours and twenty minutes,		93,485,513

Indicator Diagrams. From the Worthington Duplex Pumping Engine, taken during the experiments at Belmont.
Scale 16 pounds to one inch.

RECAPITULATION.

Total weight of water evaporated, in pounds, in forty-eight hours and twenty minutes	318,181
Total weight of water evaporated, in pounds, in one hour,	6,583

Cubic feet of water evaporated in one hour, . .	107
Total weight of water elevated, in pounds, in forty-eight hours and twenty minutes, . . .	93,485,513
Total height of water elevated in feet, . . .	208

Having the amount of water evaporated in a given time, and the amount of water lifted to a given height, we can arrive at the horse-power of the boiler very readily :

$$\frac{93,485,513 \times 208}{48{\cdot}33 \times 60 \times 33,000} = 204 \text{ horse-power.}$$

The above result does not take into account the friction of the water through the pumps and main, nor that of the engines. The diagrams taken during the test, from the high and low pressure cylinders, amounts to 253·20 horse-power.

HORSE-POWER.

Per cubic foot evaporated, as per result.

Horse-power per cubic foot of water, including friction, .	1·90
Horse-power per cubic foot of water, as per indicator card,	2·48

It would seem, therefore, that the usual allowance regarding the amount of water evaporated per horse-power, viz.: one cubic foot of water, per horse power, per hour, is at variance with the experiments made at Belmont. The experiments made there were exceedingly close and precise. There is no doubt but the facts resulting from them can be implicitly relied upon; they show that the evaporative value of these boilers is equal to about 30 pounds of water per horse-power per hour, with a consumption of about four pounds of coal.

Philadelphia, January, 1873.

The Velocity of Light.—M. Fizeau, has lately published* the results of a series of very elaborate experiments, made with a view to the most accurate determination of the velocity of light.

The source of the ray was a jet of oxyhydric gas, and the distance between the two stations, as found by careful triangulation, was 33,827·1 feet, with a probable error of 0,001. Six hundred and fifty satisfactory observations were made, the mean of which, multiplied by the index of refraction 1·000 3 gave 185,386 miles per second as the velocity of light to an approximation of 0·003. This result agrees with that previously determined by Foucault, and also confirms the value of the sun's parallax (8″ 86), obtained by La Verrier.

* Les Mondes.

NOTES FROM THE UNIVERSAL EXPOSITION AT VIENNA.

(From our German Correspondent.)

Now, when the time appointed for the opening of the World's Exposition at Vienna is so near at hand, the attention of the public is naturally directed not only towards the Exposition itself, but also to the city of Vienna in general, while, on the other hand, the inhabitants of the latter are doing their very best to prepare for the reception of their expected visitors. Owing to the active zeal of all nations for representation in the Exposition, it assumes larger and larger dimensions, so that in spite of the very great area placed at the disposal of the exhibitors, the complaint of insufficient space has become permanent. That part of the Exposition especially which is to represent the German Empire will be very extensive. The space reserved for Germany within the Palace of Exposition is far from sufficient, and the German Commission have therefore erected several large pavillions between the Industrial Palace and the Machine Hall. The extremely mild winter favors the uninterrupted continuance of all kinds of work without any difficulties, and it can hardly be doubted that the Exposition will be opened at the appointed time and with all the arrangements completed. My former assertion regarding the insufficiency of light in the Palace of Exposition I still maintain, however, especially as far as the Rotunda is concerned, although the official organs of the press endeavor in every way to bring light into this darkness.

As regards the city of Vienna itself, its authorities have to provide, before all other things, suitable public conveyances. For this purpose several new omnibus and horse car lines have been organized. A belt-railroad for locomotives, which had likewise been planned, has however, thus far not been built. But the mountains *Kohlenberg* and *Leopoldsberg*, in the immediate vicinity of Vienna, which offer beautiful prospects and favorite pleasure grounds for excursions, have been connected by two roads, a rope-road and a road with a toothed rail, after the model of the Rigi and Mt. Washington road. For the planned belt-road and for similar narrow gauge roads, engineer Mannhart, of Vienna, has constructed a locomotive which possesses essential advantages, and has been tested already with the greatest success. The subjoined drawing (Fig. 1) furnishes an illustration of this engine, of which the following is a description.

Mannhart's locomotives are all tank engines, and are, compara-

tively, of enormous power. 1st. Locomotives for industrial, forest and mountain railroads of from 0·632 meters, equal 24 Vienna inches gauge. Two pair of coupled wheels of 0·800 meter diameter, the rear pair of which is on the driving axle, with a wheel-base of 1·500 meters, are below the boiler in front of the fire-box. Both drivers can be braked in front. The brake-spindle is placed at the railing around the footboard. The cranks and bearings of the wheels are after Hall's system, the manner in which the weight is distributed and in which the springs are applied is especially favorable. The two outside cylinders, which are 1·432 m. apart between centres, have a diameter of 0·240 m.; the stroke of the piston is 0·425 m. The boiler, with a diameter of 0·800 m., contains 88 tubes, of a length of 2·540 m., with an outside diameter of 0·046 m. The total heating surface is 34·375 square m.; that of the fire-box 2·792 square m.; that of the grate 0·545 square m. The ratio between the direct and the total heating surface is consequently as 1 : 12·3; the ratio between the grate and the heating surface is as 1 : 63, an extraordinarily favorable one, which presupposes the great power of the machine and very great economy in the consumption of fuel. Moreover, the total weight is subservient to adhesion. The copper fire-box roof is stay-bolted to the iron one, after L. Becker's system, which lessens the overhanging weight of the fire-box, which is 0·810 m. long (the front of which is 0·440 m. distant from the centre of the driver), and avoids too great an elevation of the fire-box, thus favoring a better lookout.

The cubic contents of the water-tank is 1·5 cubic m., and that of the coal bunker 0·75 cubic m. The water tanks are partly at the side of the barrel of the boiler and partly under it, between and above the axles in the form of a cross. The sand-boxes are on both sides of the frame. A dome of a diameter of 0·500 m. is placed near the front of the barrel of the boiler, which is riveted together in only two sections, and contains a safety valve and the regulator. The rear safety-valve, the whistle, the injector-cock and the pressure gauge are placed upon a small cast iron dome, with a diameter of 0·210 m., whose whole arrangement must be pronounced as very ingenious. Blast-pipe, blow-off cock, the manhole and water-gauge are arranged in the usual manner. The stack is conical, with Klein's spark arrester.

Stephenson's link motion is placed outside. The eccentrics are fitted on return cranks of the driving axle; the steam chests are

Fig 1.

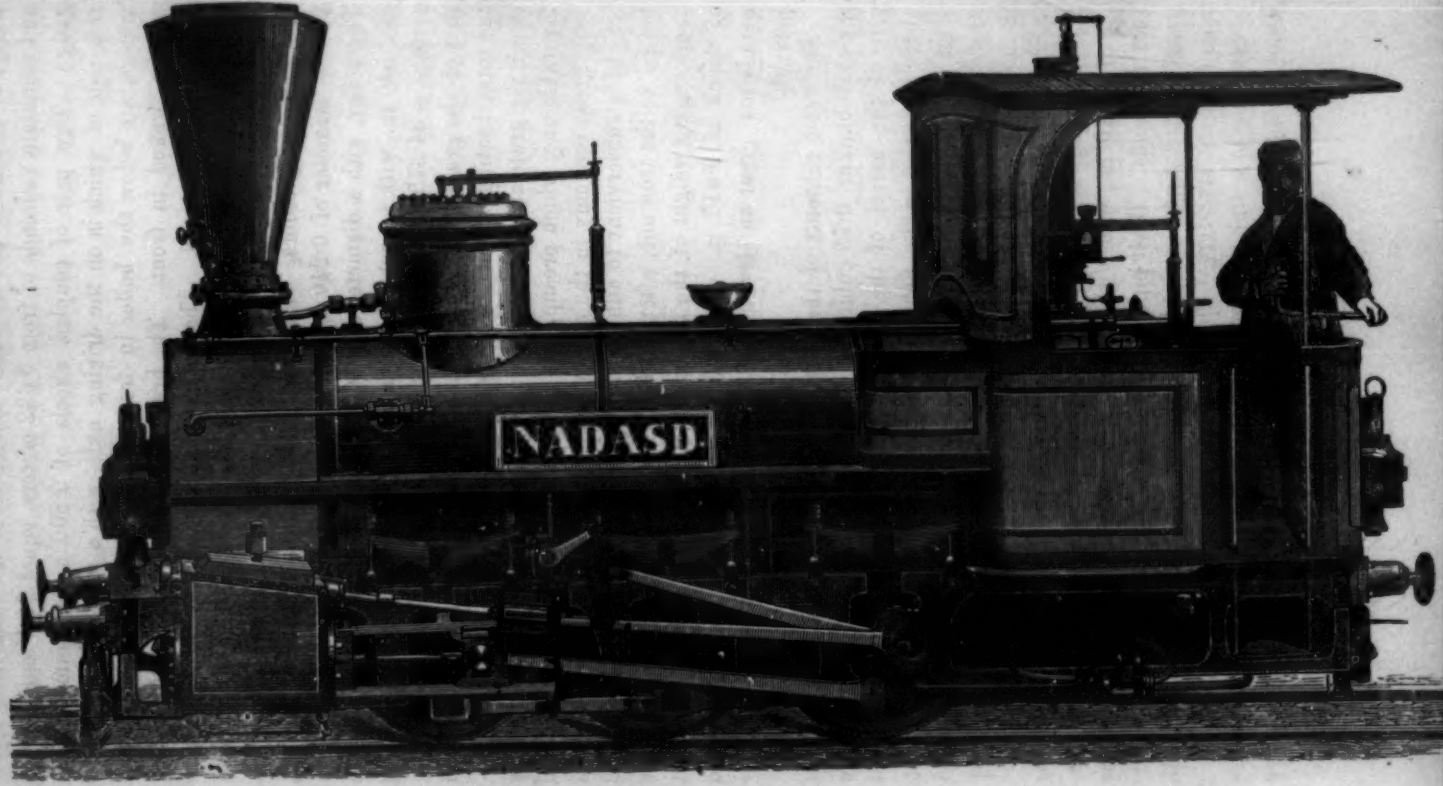
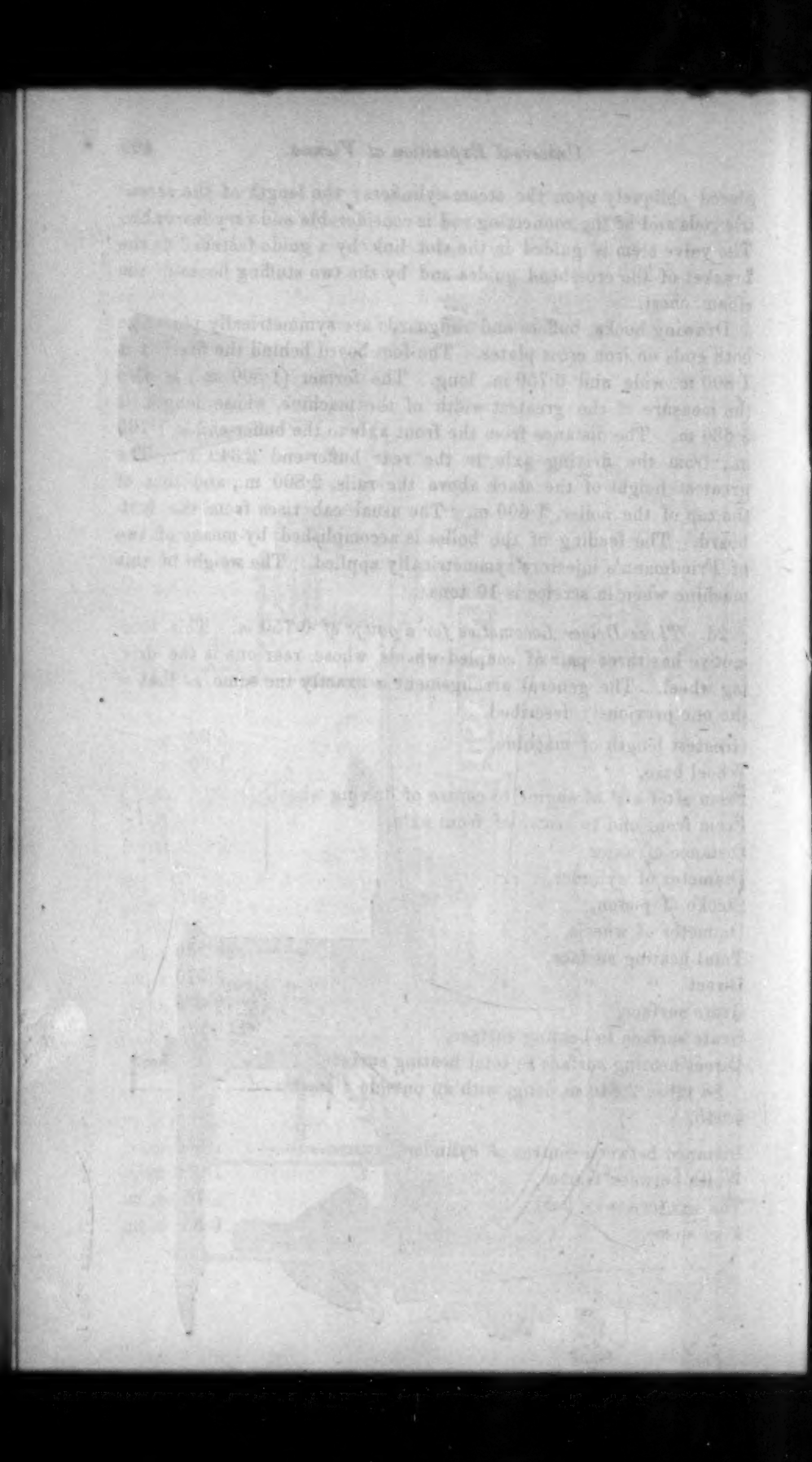


Fig 1.



placed obliquely upon the steam-cylinders; the length of the eccentric rods and of the connecting rod is considerable and very favorable. The valve stem is guided in the slot link by a guide fastened to the bracket of the crosshead guides and by the two stuffing boxes of the steam chest.

Drawing hooks, buffers and railguards are symmetrically placed at both ends on iron cross plates. The foot board behind the fire-box is 1·800 m. wide and 0·750 m. long. The former (1·800 m.) is also the measure of the greatest width of the machine, whose length is 5·630 m. The distance from the front axle to the buffer-end is 1·700 m., from the driving axle to the rear buffer-end 2·340 m. The greatest height of the stack above the rails, 2·800 m., and that of the top of the boiler, 1·600 m. The usual cab rises from the foot-board. The feeding of the boiler is accomplished by means of two of Friedmann's injectors symmetrically applied. The weight of this machine when in service is 10 tons.

2d. *Three-Driver Locomotive for a gauge of* 0·750 *m.* This locomotive has three pair of coupled wheels, whose rear one is the driving wheel. The general arrangement is exactly the same as that of the one previously described.

Greatest length of machine,	5·930 m.
Wheel base,	1·800 m.
From after end of engine to centre of driving wheel,	2·340 m.
From front end to centre of front axle,	1·790 m.
Distance of axles,	0·900 m.
Diameter of cylinder,	0·290 m.
Stroke of piston,	0·425 m.
Diameter of wheels,	0·800 m.
Total heating surface,	38·380 s. m.
Direct " "	3·070 s. m.
Grate surface,	0·639 s. m.
Grate surface to heating surface,	1 : 60
Direct heating surface to total heating surface,	1 : 12·4

88 tubes 2·840 m. long, with an outside diameter of 0·045.

Distance between centres of cylinders,	1·550 m.
Width between frames,	1·050 m.
The wanter-tanks hold	1·75 c. m.
Fuel space,	0·85 c. m.

Weight of engine when empty,	12 tons.
Weight when in service (at the same time weight of adhesion),	15 tons.
Pressure of steam,	10 atmospheres.

3d. *Locomotive with* 8 *coupled wheels for a gauge of* 0·750 *m.* Has four pair of coupled wheels, the last but one being the drivers.

Greatest length of engine,	6·435 m.
From end to rear axle,	2·340 m.
Distance between centres of adjoining axles,	0·760 m.
Total wheel base,	2·280 m.
From front axle to end,	1·815 m.
Diameter of cylinder,	0·320 m.
Stroke of piston,	0·425 m.
Diameter of wheels,	0·760 m.
104 tubes 3·300 m. long, of an outside diameter of	0·045 m.
Total heating surface,	52·25 s. m.
Surface of fire-box,	3·75 s. m.
Grate surface,	0·888 s. m.
Ratio of grate surface to heating surface,	1 : 59
" " direct to total " "	1 : 14.
Steam pressure,	10 atmospheres.
Water-tanks,	2·25 c. m.
Weight of empty engine,	17 tons.
" in service (weight of adhesion),	22 tons.

The last two kinds of engines have the brake invented by Mannhart. The brake-blocks are placed above, between the wheels, on a shoe guided by the boiler supports. They are worked by a lever, connected with them by a link. The spindle lies horizontally; the effect is almost instantaneous, since the brake-blocks, when pulled, press the middle wheels not only to the boxes, but also to the rails. The outer wheels are pressed only to the boxes; a possibility of running off the track is thereby avoided.

There is no doubt that these engines can be furnished at less expense by omitting Hall's system. To be sure some water room is lost by the greater narrowness of the frames, and the motion loses some of its ease; but since the water room is still sufficient for short distances, and since no greater rates of speed are wanted, the transferring of the frames within the wheels might recommend itself. Such machines are at present built in the factory of the Forest &

Mountain Industrial Company, at Mœdling, near Vienna, and have already before been built in the machine works of G. Sigl, in Vienna.

The following table shows the capability of these locomotives in hundred weights (= 50 kilog).

Grade.	For two drivers.		For three drivers.		For four-drivers.	
	from cwt	to cwt.	from cwt.	to cwt.	from cwt.	to cwt.
1 : ∞	4800	5400	6500	7500	10460	13500
1 : 500	3200	3800	5200	6000	7600	9500
1 : 300	2800	3200	4400	5000	5960	7800
1 : 200	2200	2600	3600	4000	4760	6500
1 : 150	1800	2000	2900	3300	3900	5100
1 : 140	1700	1900	2800	3200	3750	4900
1 : 130	1650	1800	2600	3000	3600	4700
1 : 120	1580	1700	2500	2900	3400	4500
1 : 100	1500	1600	2100	2400	2960	3900
1 : 80	1200	1300	1800	2100	2420	3200
1 : 60	850	1000	1380	1600	1880	2500
1 : 50	680	820	1100	1300	1560	2000
1 : 40	520	600	900	1100	1200	1600
1 : 30	350	460	620	740	840	1200

For railroad construction the factory of G. Sigl, in Vienna, has likewise built a very convenient locomotive, which is at the same time provided with a contrivance that allows it to be transported on ordinary roads. This locomotive (represented in Figs. 2 and 3) has received the name of *portable locomotive.* It is a four-wheeled tank engine, of normal gauge, has a short wheel base, in order to be available for sharp curves, and buffers, the height of which, from the rails, can be changed. At both sides of the boiler water-tanks are attached; both pair of wheels are coupled, and the brake is between the wheels. Fig. 2 shows the locomotive ready for service. For transportation on ordinary roads the front wheels are bound with cast iron tires, the construction and fastening of which may be inferred from Figs. 4, 5 and 6. Under the platform a carriage with an ordinary wagon-pole is fastened, while the rear wheels of the locomotive are raised from the ground.

Fig. 2.

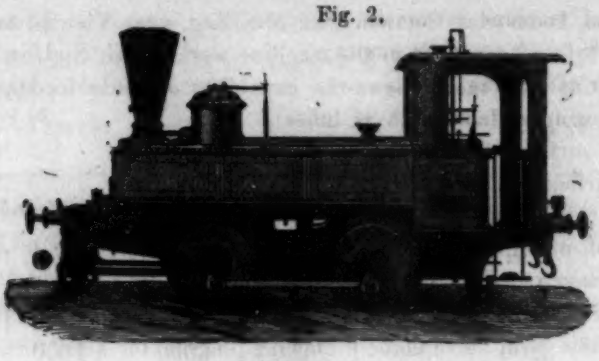


Fig. 3.

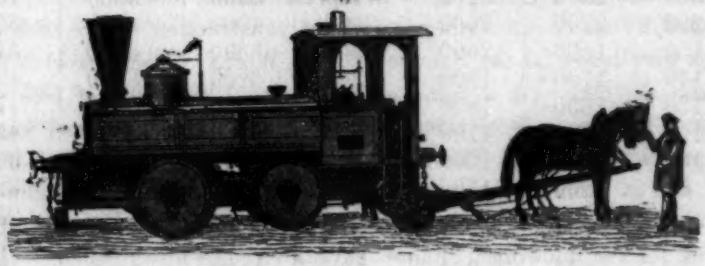


Fig. 6.

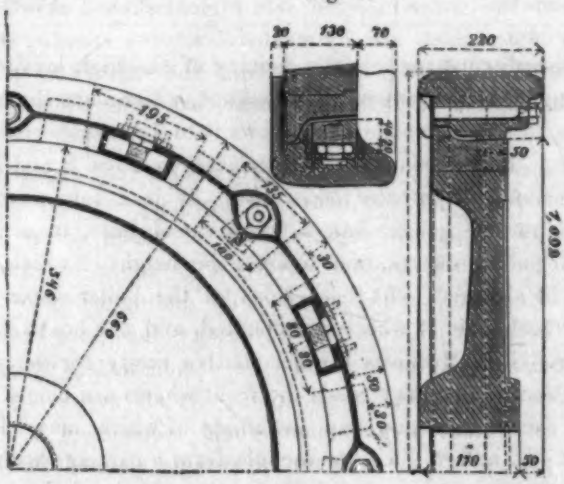


Fig. 4. Fig. 5.

This locomotive, as well as the apparatus for transportation, have been found very serviceable, and they are in constant demand. Its main proportions are as follows :

Weight of machine in service,	18 tons.
" " " when empty,	15 tons.
Diameter of driving wheel,	1·100 m.
Total heating surface (with 84 tubes),	38·867 s. m.
Heating surface of fire-box,	3·242 s. m.
Grate surface,	0·523 s. m.
Diameter of cylinder,	0·265 m.
Stroke of piston,	0·500 m.
Performance on $\frac{1}{40}$ with $2\frac{1}{2}$ (German) miles per hour, exclusive of machine,	6500 cwt.

The same firm have made a blowing engine for blast furnaces, of which I subjoin a photographical representation, and which is distinguished by many interesting details of construction. Two such engines were made for the Schwechat Iron Works. Each machine furnishes the blast for a furnace that melts 1200 cwts. of iron per day. The engine is of the compound condensing type, and has a poppet valve motion. The small steam cylinder has a diameter of 33″ and a stroke of piston of 6′ $10\frac{3}{4}$″; the large steam cylinder 100″ diameter and stroke of 9′ (all in Vienna measurement). The valves for the blowing cylinder have a circular arrangement. The throttle-valve for the regulation of the blast is new and interesting. It consists of two cones inserted into a globe-shaped chamber of the conducting pipe, which are, by means of a screw spindle, that has a right and left hand thread, removed from one another when the blast is to be shut off, and to be brought near each other when the blast is put on.

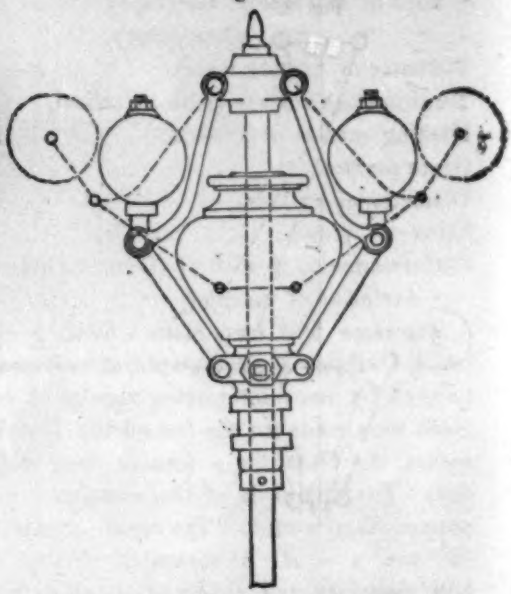
A street locomotive by the same firm is also very ingeniously constructed, but somewhat too heavy for ordinary streets. This locomotive has two separate engines, each of which drives a wheel.

I have to mention as another novelty a governor, invented by Dr. R. Proell, Engineer, which is specially distinguished by its simplicity. Whether it possesses the advantages that have been claimed for it and theoretically proved, must be demonstrated by experience derived from its practical application. At all events its pleasing form and convenient arrangement would recommend it even if it should not possess *all* the eminent advantages claimed for it by the inventor. The following description will enable experts to judge for themselves.

As the wood-cuts in Figs. 1 and 2 show, Dr. Proell's governor is to be considered as an improvement on Porter's governor. The ball

Fig. 1.

Fig. 2.



is taken from the joint and placed upon a separate arm, which forms a definite angle with the lower connecting link. The angle BDE is a stationary knee-shaped piece, which, in the upper position of the governor in Fig. 4, occupies the position indicated by the dotted lines. By this change in the position of the balls, Porter's governor, in which the balls swing in a circle around the stationary points at C, has been made pseudo-astatic, *i. e.* the sleeve accomplishes its way, which lies between the extremes of 50 mm. and 75 mm., no longer with great changes of velocity (10—15 per cent.), but with comparatively small changes of velocity (2—4 per cent). The ball-centres in Proell's governor move in a circle whose centre lies at more than double the height on the other side of the spindle, pretty nearly in *a*. Since the effect of external forces upon a governor is independent of the manner in whch the ball-centres are led in appropriate orbits, it is evident that the working of this modification of Porter's governor is nearly identical with that of a governor in which the dotted lines, AB, are actually carried out as rods, and the ball-centres, B, are led in a circle around A.

Fig. 3 shows the hitherto usual construction of pseudo-astatic governors with crossed arms; figs. 2 and 4 the change in the connection of the joints devised by Proell.

Fig. 3.

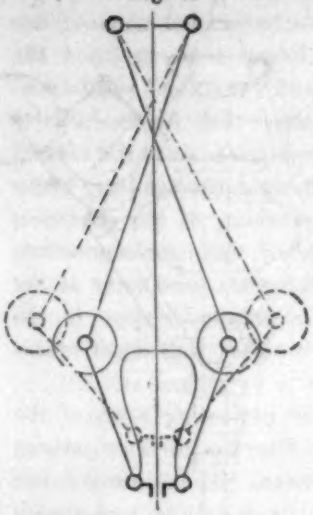
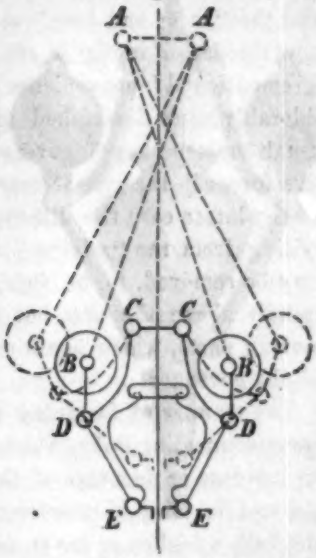


Fig. 4.



A comparison of the two constructions represented in figs. 3 and 4 shows, in the first place, that the total height of the governor, which, in consequence of the crossed arms, is considerable, is diminished by one-half in Proell's governor (fig. 4). The entire length of the spindle is very small, and, therefore, its journal requires only a box of small height. A prolongation of the spindle beyond the stationary points, C C, will, even with very large governors, not appear as necessary.

By inserting the angles E D B, as well as by judicious bending of the upper arms, C B, there is, moreover, a comparatively large space gained for applying a heavy counterbalance, and it becomes possible to fasten large balls on the projecting arms. Upon the weight of the parts of the governor depends its capacity for work. Since now the masses in Proell's governor, in spite of its compendiousness, are very considerable (in the governor marked as III in the subjoined table the balls and the counterbalance alone weigh 54 kg.), it has also a considerable capacity for work, *i. e.* it works very energetically. But Proell's governor excels by still another advantage other governors, in consequence of the compendious arrangement of the joint-connections. At a sudden change in the velocity of the governor the balls, in consequence of their inertia, have the tendency of leaving the plane in which the joints are connected.

The greater this tendency, the stronger is the so-called "edging" and the "wear and tear" at the forks of the suspended arms. Since now the latter in fig. 3 are considerably longer than in fig. 4 the forementioned inconvenience of "edging" and "twisting" will be considerably more diminished in Proell's governor than by the hitherto usual construction of governors with crossed arms, since the respective forces in the former case work through much shorter lever arms. In the latter case the disadvantage to the working of the governor, arising from the "edging" and "twisting" of the joint-connection, may be removed, to be sure, by making the arms stationary at the spindle above the urn, but this produces a greater friction in the moving parts, which again considerably diminishes the sensitiveness of the governor.

The manner of fastening the balls on the projecting arms of the lower connecting links, which is peculiar to Proell's governor, allows an increase or decrease of the distance between the ball-centre and the middle joint by substituting for the little disc lying underneath the ball, a higher or lower one.

In proportion as the distance is increased or diminished the approach to the astatic condition is likewise effected. In the governor, IV, in which the "sleeve," during a change of velocity of 3 per cent. (without regard to resistance), performs a stroke of 75 m. m., the height of the little disc underneath the ball is 12 m. m. If this is replaced by one twice as high, the total increase of velocity is 2 per cent.; if the disc is entirely removed it only amounts to 4 per cent. The approach to the astatic condition is, therefore, doubled with reference to the extremities of the balls. It is possible, therefore, by merely changing the discs under the balls, to ascertain for every given case by experiment the height of the situation of the balls which corresponds to the most favorable working of the governor; but since at the same time also the number of revolutions of the governor changes within definite limits, a displacement of the balls may be made a means of adjusting the machine for another number of revolutions. At a mean position of the ball, for example, the governor, IV (in the table), makes in the average, without regard to the resistance of friction, 81 revolutions; at the lowest position of the balls (12 m. m. lower) 83; at the highest (12 m. m. higher) 79 revolutions.

Finally, it is to be mentioned that very considerable masses may be disposed of in Proell's governor without causing their construction

to exceed the practicability of execution. Governors, the total height and greatest width of which amounts to only one meter, have a mass of about four cwt., and are, therefore, adapted to a high degree to be used in all those cases in which the regulation of the motor requires a considerable expense of work, as, for example, on water-wheels and turbines for the direct movement of the sluice, and on steam engines where the expansion valves are to be directly moved by the governor. Geometrically all governors resemble each other. On examining the sketch given in fig. 4, which is drawn in three-eighths, three-twentieths, one-fourth, three-fourteenths of the actual size, it will be found to represent the proportions marked as I, II, III, IV, in the subjoined table.

That the number of revolutions of Proell's governor is comparatively a small one must be pronounced as not unessential. For with governors of a great number of revolutions the arrangement for increasing the velocity has often its inconveniences. Likewise the lost motion in the adjusting apparatus, arising from wear and tear, has no great injurious influence upon the manner of working of the governor, because the elevation of the sleeve according to the size, vacillates between 50 and 75 m. m., *i. e.* convenient values. The excellent working of Proell's governor has already, practically, been established, and observations and experiments have demonstrated that the value of a change in the motion of from 3–4 per cent. for the total elevation of the sleeve which underlies the constructions is the most convenient approach to the astatic condition.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at the rooms in New York, February 19th, 1873.

The Secretary presented the following discussion of a paper "upon the character and position of neutral axes as seen by polarized light," by Louis Nickerson, C. E., of St. Louis, Mo., read before the Society December 18th, last.

Col. Merrill.—This paper opens a field for examination which promises the most useful results in a matter of vital interest to engineers:—the laws of strains in materials used for construction. The plan of using glass to find out these laws, brings to mind the practice of physicians in ancient times of determining the laws of the human body, by experiments upon those of the lower animals.

In examining the action of strains within opaque bodies, the method by analogy seems to be the sole one—aided, of course, by what is visible on the surface and detected after fracture.

Further experiments will probably enable us to decide with fair accuracy what is the magnitude of an unknown strain on a glass column, by comparison with the observed effects of a known strain upon a similar column.

The proposed strengthening of tubes by external rings at regular intervals, is a curious result of the experiments, and—if confirmed by practice—a valuable discovery. The whole discussion illustrates the interdependence of all branches of physical science; and that no discovery is to be considered useless, no matter how far it is apparently removed from a practical application.

MR. MCALPINE.—The civil engineer has rarely to deal with glass as a material of strength; still, evidently, it will be affected in the same way as any similar material—as cast iron. It is a characteristic of this age, that every discovery in science is made useful to the engineer or constructor.

Some years ago, Prof. Airey devised a system of measuring the strains in each member of a truss, with a model in steel, of which he had exact duplicates. When the model was loaded, a member was struck, and the strain upon it measured by the load borne by the duplicate when in accord. There we have *sound*, and here we have *light*, to aid in solving an important problem.

GEN. ELLIS.—Westheim, of Paris, invented an instrument for the determination of strains and pressures by the colors of polarized light. Mr. Nickerson's examinations are in the right direction, and it is hoped he will pursue the matter further.

What we want to know is, the elastic resistance to tension and compression in any one substance, and the effect of a weight upon a beam of the same substance; then knowing, by experiment, the elastic resistance in both directions of other substances, we reason upon the position of the neutral axes of beams made therefrom.

Writers upon the strength of beams err in assuming that equal strains extend and compress the same substance equally, (thereby locating the neutral axis of horizontal strains in the middle of a rectangular beam;) also, that the elastic and ultimate resistances are proportional.

How can polarized light show a neutral axis in a glass beam, supported at the ends, and weighted in the middle, instead of a neutral

point under the weight? Everywhere in the beam except at the central point, there are diagonal strains, which will, as well as the horizontal strains, transmit the polarized rays.

The additional element of strength referred to in the paper, is, I think, due to the elastic yielding of fibres which, in consequence, slip upon each other, without a diminution of their ultimate strength. Otherwise, in a beam under strain, the outer fibres would be ruptured before the others were loaded.

A communication from Gen. Smith, chairman of the committee appointed at the annual convention, held in Chicago, June 5th and 6th, last, to urge upon the United States Government the importance of a thorough and complete series of tests of American iron and steel, and the great value of formulæ to be deduced from such experiments, was read, stating that information is required of what has been done in this direction by other Governments, as well as by corporations and individuals here and abroad; of new forms employed, and of new processes of iron and steel-making, and their products.

A paper by Gen. W. S. Smith, of Maywood, Ill., on "Pneumatic Foundations," was read.

The first two bridges on pneumatic pile foundations erected in the United States, were one over the Santee River, on the Northeastern Railroad, built in 1855, and the other over the great Pedee River, on the Wilmington, Columbia and Augusta Railroad, built in 1857.

The air-lock used in sinking these piles, was invented by Alexander Holstrom. It was a cast-iron cylinder, six feet in diameter and four feet high—closed at top and bottom by cast-iron plates, through which were man-holes opening downward for entrance, and bull's eyes of glass for light; two goose-neck pipes passed through the sides and bottom—one for introduction of air, and the other for the discharge of water when it would not escape through the material underneath the pile. A windlass was attached for raising the earth within the pile, all of which was removed by hand.

There were four air-pumps, set in a single frame, of such excellent construction that they served for the sinking of their foundations, those of the Third Avenue Bridge, New York, across Harlem River, and of the Leavenworth Bridge across the Missouri River, and are now being repaired for use in sinking the piles for the Little Rock Bridge across the Arkansas River.

Construction of the pneumatic pile piers for a bridge over the Savannah River, on the Charleston and Savannah Railroad, was begun

in the fall of 1859. The air-lock used was six feet instead of four feet high, and, to save weight, the cylinders of wrought instead of cast iron. Two defects were soon apparent: one, practically no natural light was admitted into the pile through the bull's eyes in the air-lock plates; those in the bottom being covered with dirt most of the time: another, the air-lock was too small to stow the material raised, so that when discharging the same, work in the pile was much delayed.

To overcome these defects, an air-lock was made of less diameter than the pile, so that an annular space was left between the two, in the plate covering the top of the latter, into which bull's eyes were introduced. Through the side of the air-lock was a pipe or trap, inclined at an angle, to discharge readily any material put into it, and arranged for closing at either end. The outer end being closed, the trap was filled with material; the inner end was then closed, the compressed air, thus cut off from the air-lock, liberated, and the outer end opened—when the material would pass out. By reversing the process, the trap was made ready to receive material again.

By this modification, no artificial light was required during the day, and at night it could be reflected into the pile without the inconvenience of candles or lamps burning in a compressed atmosphere. No detention occurred from this or from voiding the material raised, and nearly thrice as much work was done in the same time as with the Holstrom air-lock.

It was soon found that the sandy material through which these piles were sunk, could be raised by the escaping compressed air, through a discharge pipe, and delivered outside in a continuous stream. For this, the mouth of a flexible tube, fitted to the lower end of a fixed pipe, was thrust into the wet sand, and moved from place to place, as the material disappeared. The ratio of work done to that with the old air lock, which before was as 28 to 10, now became as 28 to 1.

The improvements thus introduced have been generally used since by Gen. Smith in sinking foundations by the pneumatic process. For the flexible tube, one iron pipe sliding into another, with a hempen casket between, has been substituted, with the still better results. Thereby seven men have excavated six cubic yards per hour, for several hours. By hand, two-thirds of a cubic yard per day per man is about the rate.

The late war interrupted this work, and also prevented consideration of a plan submitted to the U. S. Light House Board in 1860, for

the erection of a light house on Frying-Pan Shoals, or a similar position on the coast, embracing the sinking of a caisson from thirty to fifty feet in diameter, to any required depth less than one hundred feet; inside of which a masonry foundation of dove-tailed stones was to be laid. Soon after the war the plan was adapted to the repairing of Waugoshance Light House, located at the western entrance of the Straits of Mackinac, upon a rocky reef two-and-a-half miles from shore. It is a brick tower of twenty-four feet in diameter, eighty-four feet high from water surface to focal plane, and stands upon a foundation twenty-four feet square, consisting of a crib, filled with concrete and rubble masonry. This crib was surrounded by others filled with loose stones, all framed together into one pier one hundred feet square. At this time the timbers put in place in 1848 were decaying under the action of seas, as heavy as any upon the Northern lakes, and the ice. The utter destruction of the pier was threatened.

It was proposed to protect the tower from waves and ice by surrounding it with a strong sea-wall sixty-six feet long and forty-eight feet wide on the outside; eight feet thick, and semicircular at the ends. An annular pneumatic coffer-dam of boiler iron was built up in place around the tower large enough to enclose the wall. It was provided with two air-locks, each having a rectangular trap, through which material and workmen passed, and a windlass driven by steam. The dam was suspended by chains from beams resting upon the woodwork of the old pier, and with stones loaded somewhat in excess of its buoyancy. For six feet below the water surface, the crib timbers of pine, twelve by twelve inches, built up solid, and strongly drift-bolted with round one inch iron bolts, had to be cut through. The reef then reached was made up of boulders varying in size from a hen's egg to ten tons weight. The large ones, when found under the edge of the caisson, were first split with plugs and feathers, or undermined, drawn into the caisson, and then split. In some instances, where large stones rolled against the dam and kept it from sinking, the dam was allowed to raise, and the stones were rolled inward.

The dam was sunk to the depth of 12¼ feet below the water surface, and six feet below the foundation of the tower, which, though not upon bed rock, as expected when the work was begun, was where the boulders (which had lessened in size as the depth increased) were most perfectly compacted together, and below the scouring action of the waves, from which the dam was protected by the remaining portion of the cribs. The bottom of the dam was then sealed with two successive

layers of the quickest setting Louisville cement, each six inches in depth, and set under water, which, when the air pressure was reduced, entered through holes left for it in the layers.

It was found the twelve inches of cement thus laid, would not, after four days' setting, resist the pressure of water outside, hence the first three courses of masonry, each two feet thick, were laid in a compressed atmosphere. The stones were dowelled together with iron pins $2\frac{1}{2}$ inches in diameter; the end of each pin was drilled one inch in diameter, three inches deep, and sawn, so that when in place and a taper bolt driven therein, the dowell was permanently enlarged.

When the wall was finished, the space between it and the tower was filled with concrete, and covered with flagging. The coffer-dam, which might have been removed for use elsewhere, was left in place.

Work could only be done in the months beginning with May, and frequently it was interrupted by storms. During the first season the chamber to receive the dam was excavated; the machinery was put in place; the dam built and sunk four feet. During the second season, the sinking was concluded, and seven courses of masonry laid. And during the third season, the work was entirely finished. An average force of forty men was employed. The entire cost, including a new dwelling for the light-house keeper, was less than $200,000. This is the first instance of the sinking of a pneumatic coffer-dam or caisson in this country.

After the completion of this work, Gen. Smith, in 1869, proceeded to put down at Omaha, for a bridge across the Missouri river, the first pneumatic piles sunk west of the Alleghany mountains, and to a depth greater than ever before reached—eighty-two feet below the water surface. The material was very difficult to penetrate. It consisted of a fine silt, stratified with layers of coarse sand and tough blue clay—the latter not more than two feet deep, and with a stratum of pebbles or gravel one and a half to two feet deep next to the bed rock.

The first pile went down vertically; the second, after sinking twenty-seven feet, took an inclination which could not be corrected in the next twenty feet by the various means applied, which, although they failed here, in many other cases have succeeded at a depth of from forty to fifty feet. Generally, the most effective method is to excavate the material under the pile, and, with heavy wooden wedges, firmly wedge up the lowermost edge; then, by letting the air escape suddenly, bring the atmospheric pressure and the weight of the pile to bear like a blow. In this case the silt came in so rapidly as to carry the wedges before it.

Another cylindrical section was put in place, thus adding ten feet to the length of the pile, making it sixteen feet, and, with the air-lock, twenty-two feet above the earth surface. A strong frame of twelve by twelve inch timbers was laid down for a fulcrum; blocks and falls were attached to the air-lock, and a severe strain was put upon the pile. The material was again excavated, and, instead of the wedges, a strong beam, cut to the segment of a circle, put down. The pressure was let off, and the pile descended, but without any correction of the inclination, although the timbers of the fulcrum were broken.

A pine strut, eight by eight inches, eleven feet long, was set at a slight angle—its top against the leaning pile, and its foot against the pile already in place, without avail, and at last the cylinder broke off twenty-seven feet below the surface, where there was a "cold shut" in the metal.

With fifteen feet of sand in the cylinder, forty-five pounds air-pressure to the square inch, did not lift the piece broken off; but twenty-seven pounds were sufficient after the sand was removed.

This is the only opportunity he has had to measure approximately the friction on a cast-iron pile. The friction per square inch of surface in contact, before the sand was removed, was greater than 1·77 lbs., and after it was less than 1·39 lbs. This friction must vary with the depth of material, and is diminished when the earth is loosened by the passage of air currents through it. The case instanced differs from that of a pile in place under a load. An important subject of inquiry is—What should be taken as the safe resistance of such a pile, in sand, to sinking alone? Where no bed rock can be reached, as along the lower Mississippi, and on the Gulf coast, it may be desirable to sustain structures upon piles or caissons, resting wholly in and on sand.

The next two piles were put down without great difficulty—one at the rate of ten feet per day. To cause the piles to sink, they were loaded by filling the cylinders with stones, except a central passage, or well-hole. Frames built within the cylinders, kept the stones in place. After a certain depth was reached, it was necessary to increase the downward pressure on the pile, by allowing a portion of the compressed air to escape; the pile would then sink from two to four feet at a time. The top of the bottom cylinder was covered with a cast-iron diaphragm, through which there was a manhole, closed by a valve opening inward, which, when shut, prevented more sand from entering the pile, while sinking, than would fill the lower cylinder;

thereby the tendency to "lurch," and the disturbance of outside material, was lessened.

At this stage of the work, Gen. Smith was succeeded by Mr. Theo. E. Sickles, who successfully employed levers in forcing the piles down, and corrected the inclination by drilling holes through the higher side, at different heights, through which the compressed air escaped; loosened the outside material, and thus lessened the friction against the pile.

Gen. Smith then sank the piers for the railroad bridge across the Missouri river at Leavenworth, Kansas—three in number (two in the river and one on the east bank)—upon which, and a stone abutment, three spans, each 340 feet long, were erected. This was finished in two years after its commencement. The difficulties encountered were similar to those of Omaha.

The following conclusions are deduced from an experience of fourteen years in sinking pneumatic pile foundations:

1st. The greatest difficulties to be overcome are, first, in keeping the pile vertical; for this it should be made to follow the excavation without a reduction of air-pressure: and, secondly, in "righting" the pile when inclined; for this, wedging under the bottom, or propping the top on the lowermost side, and drilling through the uppermost side, are the best means yet tried.

2d. The "air-lift," as described, is the cheapest and most efficient method of removing sand or mud from within a pneumatile pile or caisson.

3d. A strong and reliable pier can be always built of pneumatic piles—their number, diameter, and the thickness of metal being determined by the conditions of the case.

4th. In cold climates, these piles may be fractured by frost—to prevent which, a filling below the frost line, from two to five feet deep, of asphaltic concrete, is recommended.

5th. Where suitable timber and stone are to be obtained at reasonable prices, a single pneumatic caisson can be sunk with greater certainty and at less cost, than a pier of three or more pneumatic piles, where it has to be sunk for a considerable depth through a soft material to a hard one. A pier of masonry on such a wooden caisson, cellular, with its walls well drift-bolted, and its interior carefully filled with concrete or rubble, is the cheapest and best bridge foundation yet devised.

6th. Concrete does not "set" well under air-pressure. The water

was let in through a pipe inserted therefor in the cement, to cover the successive layers as put down. Usually, cement, five feet in depth, would seal the pile; the remainder was added in the open air.

DISCUSSION.

MR. MARTIN.—The first work he had to do in sinking the pneumatic pile piers for a bridge across the Savannah river, on the Charleston and Savannah Railroad in 1861, was to straighten up a cylinder which was about thirty feet in the sand, and considerably inclined. The method described by Gen. Smith, of excavating underneath the lowermost edge of the pile, wedging it up firmly, and then, when severely strained in the right direction by strong tackle, causing the pile to go down by suddenly letting the pressure off, did not succeed, although the pile descended two feet or more. He then excavated under the upper edge, as much as possible, so that the escaping air passed through and loosened up the material on that side; wedged up and strained the pipe as before, and with a battering-ram, made of a twelve inch squre oak timber, twelve feet long, and in the middle suspended from shear-poles, struck successive blows against the top of the pile while it was descending, it was thus quickly brought into position.

A pneumatic pile is easier kept vertical than straightened afterward. In most cases it may be guided in its descent by a platform attached to wooden piles driven around it.

Gen. Smith presented a plan for sinking any depth pneumatic piles and caissons, through sand, whereby the excavation is made without exposing workmen generally to the injurious effects of compressed air, which increase with the depth, and, below sixty feet, are dangerous.

For a pneumatic pile, there should be a short section at the bottom, covered with a plate, through which there are a man-hole and valve, a supply, and one or more discharge pipes—the latter made telescopic, and with joints, so that a workman, standing on the plate, may cause the mouth of the pipe to traverse the surface to be excavated beneath the pile. Thus air, forced into the closed section through the supply pipe, would escape through the discharge pipe, and carry with it the material to be removed.

In a caisson, the same principle may be carried out. Men need enter the compressed air chamber only to remove an unusual obstruction.

Such a method is required in sinking foundations to very great depths. The greater the depth, the more efficient is the *air-lift* described.

Of course, this plan cannot be adopted where the material to be removed will not yield and flow with an air current.

A paper by Robert Cartwright, C. E., of Cleveland, Ohio, on "The Manufacture of Pneumatic Piles," was read.

The bridging of the Missouri river was a necessity to the railroads connecting the east and west of this country. The river is a rapid running, turbid stream, with a bed of treacherous, shifting material, and a channel which changes at every flood.

The bridge at Omaha has eleven spans, 250 feet long; and at Leavenworth, three spans, 340 feet long; both Post's truss, upon pneumatic pile piers. The manufacture of cylinders for these is here described:

First, there was built a brick pit, forty-seven feet internal diameter and fourteen feet deep, water-tight; with a foundation in the centre for a twenty-five ton crane, and four buttresses therefrom, dividing the pit into quarters, each to take two moulds.

For access to the moulds, and to supply air during casting, and subsequent cooling, there was a tunnel from each quarter to a shaft sunk outside of the pit. Each mould was built of fire-brick, laid in loam, upon a level cast-iron bed plate, and covered with another similar plate—the two being firmly bolted together. Outside the mould was a casing of sheet-iron—a space of a foot between the two being filled with spalls, cinder, and moulding-sand, which allowed the passage of escaping gases. The remaining spaces in the pit were also filled with sand. From the centres of each bed plate up to the top of the mould was a vertical wrought iron shaft, upon which the core barrel centred. The inside of the mould was coated about five-eighths inch thick with loam, brought to a true surface with a "strike" board revolving about the shaft. That the castings might be of uniform section under the difference of ferro-static head, the diameter of the mould at the bottom was made three-sixteenths inch less than at the top. The core-barrel consisted of six or more staves, or circular segments, strengthened by ribs cast on them, and bolted to two circular spiders, which were attached to a central hollow shaft, bored to receive the shaft fixed in the bed-plate of the mould—the whole being so arranged that the hollow shaft and spiders could be withdrawn together, and the staves left in position, to be afterwards removed singly. The barrel was coated with loam, to which a small quantity of chopped hay had been added—no rope being used.

When the mould was coated and dried, and the core in place, it

was covered with a plate or trough, coated with loam, and well fastened down; through this were twelve holes, one and a half inch in diameter for pouring "sprues," and six elliptical holes about three and a half by one and a half inches for "risers;" the last were about twelve inches high and six inches diameter at top, and were an effectual substitute for a "sinking head." A casing was then placed about the covering plate, forming a "runner" around the whole top of the mould, connected with a pouring basin, which had two outlets, each stopped by a "straining" gate, to retain the slag.

The mould was filled to the top of the risers, the iron entering simultaneously at twelve equi-distant points, and as shrinkage took place, fresh metal was supplied, and churned with coated rods. When the iron was "set," the runner casing was taken away, the "sprues" and "risers" broken off with a sledge; and, in rapid succession, the covering plate and the several parts of the core barrel removed, leaving the red hot section just cast, in the mould, and free to shrink uniformly as it rapidly cooled, without danger to its shape or sound ness. In about fourteen hours after pouring, the section (weighing nine tons), was taken from the mould, which was then freshly coated with loam. The bricks were usually hot enough to nearly dry it. As its parts were withdrawn, the core barrel was put together, and then coated with loam, which was almost dried by the heat retained. The barrel was then placed vertically on a car, and run into the core oven, which was large enough to receive four.

The loam was prepared in a loam-mill, consisting of a revolving pan and two heavy cast-iron chasers. It was, with the addition of a little fresh material, repeatedly used.

With eight moulds and six core barrels, one, and sometimes two sections were made daily for months. Two hundred and eighty-one sections were cast, eight and a half feet in diameter, ten feet long—some one and three quarter inch and the others one and a half inch thick—each with a four and a half inch inside flange, two and a half inches thick at each end. Of these, only one was lost, and this by the breaking of a brace after the mould was nearly full. The two flanges were faced in a lathe at the same time, and then each drilled with sixty-one holes for one and an eighth inch bolts.

A paper by C. D. Ward, C. E., of Jersey City, N. J., giving "Description of Screw Piles for supporting a twenty-four inch Water Main across the Providence River, Providence, R. I.," was read.

The piles were placed in a single row, twelve feet apart, with a cap or rest, on the top of each, in which the water pipe rests.

They were each twenty-two feet long, ten inches exterior diameter, one inch thick, and weighed about 2500 lbs. The largest diameter of screws was three feet, and the pitch was ten inches; there were two threads, each making about three-fourths of a turn.

The piles descended from six to eight and a half inches per revolution, and were put down by eight to twenty-one men, with ropes attached to levers, ten and a half feet long. The direction of draft reduced the effective leverage to about seven and a half feet.

Twelve piles were put down from nine to twelve feet each, in sand and gravel, in five days. When regularly moving, the ordinary rate of sinking was about two feet per minute.

New Explosives.—MM. Houzeau and Renard have lately been quite successful in applying ozone as a reagent in chemical research.

In a paper recently made public, in which these gentlemen detail the results of some recent discoveries, they object to the method of oxidation generally pursued in organic chemistry (namely, the employment of substances rich in oxygen, such as chromic or nitric acids, sulphuric acid and bichromate of potassa, &c.), inasmuch as the action is complicated by the constituents of the mixtures employed, and their employment is often positively detrimental, on account of the somewhat elevated temperature which at times must be employed.

For these and several other reasons, the authors in question strongly recommend the employment of ozone, since it is an energetic oxidizer, and can be employed at a low temperature, and introduces the least possible amount of complexity in the investigation.

As a direct result of these suggestions, they announce that when pure benzin, boiling at 81° C., is treated with concentrated ozone, it is transformed partly into several acid products (formic and acetic acids), while at the same time there is deposited a gelatinous precipitate, to which they attach the name of ozobenzine. Dried in vacuo, it presents the appearance of a white amorphous solid. It is an eminently explosive substance. It detonates with violence when struck, or when simply heated, and for this reason is extremely dangerous to handle.

Ozobenzin is very unstable in the air. Water decomposes and dissolves it.